BULLETIN

OF THE

IMPERIAL INSTITUTE

(*Published in Quarterly Numbers*)

Periodicals

VOL. III

1905

PRINTED BY RICHARD CLAY & SONS, LIMITED
LONDON AND BUNGAY

TO BE OBTAINED FROM THE FOLLOWING AGENTS

London . . .	Messrs. EYRE & SPOTTISWOODE, East Harding Street, Fleet Street, E.C.
	Messrs. STREET & Co., Ltd., 30, Cornhill, E.C.; or at The Imperial Institute, South Kensington, S.W.
Australia and New Zealand	Messrs. GORDON & GOTCH, Melbourne, Sydney, Brisbane, Perth, Wellington, Auckland, Christchurch, Launceston, etc.
	The Government Printer, New South Wales.
Barbados . .	Messrs. BOWEN & SONS, Bridgetown.
British Guiana	The *Argosy* Newspaper Company, Georgetown.
Ceylon . . .	Messrs. A. M. & J. FERGUSON, Colombo.
Hong Kong. .	Messrs. KELLY & WALSH, Ltd.
Malta . . .	Mr. J. CRITIEN, 34, Strada Reale, Valetta.
	Messrs. WATSON & Co., 248, Strada Reale, Valetta.
Mauritius . .	The Proprietors of the *Planters' and Commercial Gazette*.
Natal . . .	Messrs. P. DAVIS & Co., Longmarket Street, Pietermaritzburg.
South Africa .	The Central News Agency, Ltd.
Trinidad . .	Messrs. MUIR MARSHALL & Co., Port of Spain.

BULLETIN OF THE IMPERIAL INSTITUTE

VOL. III, 1905

CONTENTS

THE IMPERIAL INSTITUTE

THE Imperial Institute at South Kensington was founded as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire by arranging comprehensive exhibitions of natural products, especially of India and the Colonies, and providing for their investigation and for the collection and dissemination of scientific, technical, and commercial information relating to them.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned to the use of the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee including representatives of India and the Colonies, as well as of the India and Colonial Offices, the Board of Agriculture, and the Board of Trade. This Act took effect on January 1st, 1903.

In accordance with this Act, the Imperial Institute is now managed by the Board of Trade in consultation with the Advisory Committee, through their Commercial Department. A Managing Committee has been constituted, consisting of Sir Cecil Clementi Smith, G.C.M.G., and Sir Alfred Bateman, K.C.M.G.

The Board of Trade have appointed Professor Wyndham Dunstan, F.R.S., to be Director of the Imperial Institute at South Kensington, with charge of the various branches of work there carried on.

The work formerly carried on by the Imperial Institute for the supply of general commercial, statistical, and tariff intelli-

gence is now conducted by the Commercial Intelligence Branch of the Board of Trade. (See statement as to the work of the Commercial Intelligence Branch published in the *Board of Trade Journal.*)

The Imperial Institute works in co-operation with this Branch, which is now located in the City (73, Basinghall Street, E.C.), and with the Emigrants' Information Office in Westminster.

Indian and Colonial Economic Collections.—The Collections of economic products, illustrative of the commercial resources of India and the Colonies, are arranged on a geographical system in the galleries of the Institute. Thirty-eight Colonies and Dependencies are represented.

The Collections are open free to the public daily, except on Sundays, from 10 a.m. to 5 p.m. in summer, and from 10 a.m. to 4 p.m. in winter.

A Superintendent of the Indian Section is appointed by the India Office, and the operations of the Indian Section are supervised, in consultation with the Director of the Institute, by a committee appointed by the India Office.

In consultation with the Governments concerned, these collections are being rearranged and added to (see also page ii).

Information concerning India and the Colonies, their commercial products, industries, trade, prospects for emigration, etc., may be obtained on application in the first instance at the Central Stand in the Galleries, at the General Enquiry Office, or enquiries may be addressed in writing to the Director of the Imperial Institute, South Kensington, S.W.

Central Stand for Publications and Enquiries.—A stand has been opened in the centre of the main gallery to facilitate the supply of general information and the distribution of literature. Pamphlets, circulars, handbooks, etc., containing information relating to the commerce, agriculture, mining and other industries of the principal British Colonies, and also to emigration, may be obtained gratuitously. Certain publications are for sale. (See lists on cover.) The publications of the Emigrants' Information Office, established by the Colonial Office, may also be obtained. The principal Indian and Colonial newspapers may be seen on application.

An officer of the Institute is in attendance at this stand,

which is in telephonic communication with the general offices in the main building.

The Scientific and Technical Department.—The laboratories of this Department, which occupy the second floor of the Imperial Institute, were established chiefly with the aid of grants from the Royal Commission of the 1851 Exhibition, in order to provide for the investigation of new or little-known natural products from India and the Colonies and of known products from new sources, with a view to their utilisation in commerce, and also to provide trustworthy scientific and technical advice on matters connected with the trade and industries of India and the Colonies.

The work of the Department is chiefly initiated by the Governments of India and by Departments of the Home and the Colonial Governments. Arrangements have been also made by the Foreign Office, whereby British Consuls may transmit to the Department for investigation, such natural products of the countries in which they are appointed to reside as are likely to be of use to British manufacturers and merchants.

Materials are first investigated in the laboratories of the Department, and are afterwards submitted to technical trials by experts attached to the Department and finally are commercially valued.

Except under special circumstances investigations are not undertaken for private individuals.

Library and Reading Rooms.—The library and reading rooms of the Imperial Institute contain a large collection of Indian and Colonial works of reference, and are regularly supplied with the principal official publications of India and the Colonies, and with many of the principal newspapers and periodicals of the United Kingdom, India, and the Colonies. The library also contains a collection of Indian and Colonial maps and charts.

The library and reading rooms are on the principal floor, and are entered through the entrance at the west (Queen's Gate) end of the building. These rooms are available for the use of Life Fellows of the Imperial Institute, and of other persons properly introduced.

Colonial Conference Rooms.—Three large rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Colonies for meetings and receptions.

The Cowasjee Jehanghier Hall.—The rooms in connection with this Hall are in the occupation of the Indian Section of the Imperial Institute, whilst the Imperial Institute, the India Office and the London University have the right of using the Hall for lectures, meetings, etc.

SOCIETIES OCCUPYING ROOMS IN THE IMPERIAL INSTITUTE.

(*a*) **British Women's Emigration Association.**—The British Women's Emigration Association has been assigned an office on the first floor, which is open daily from 10 a.m to 4 p.m., and advice and information respecting emigration and the prospects for women in the Colonies may be obtained there free of charge. This Association works in co-operation with the Emigrants' Information Office in Westminster.

(*b*) **Colonial Nursing Association.**—This Association has been assigned an office on the first floor of the Imperial Institute (Room 5). Its principal object is the selection of trained hospital and private nurses for service in the Crown Colonies and other British Dependencies.

IMPERIAL INSTITUTE, SOUTH KENSINGTON

Managing Committee.

Sir Cecil Clementi Smith, G.C.M.G.
Sir Alfred Bateman, K.C.M.G.

Director.

Professor Wyndham R. Dunstan, M.A., LL.D., F.R.S., V.P.C.S.

Scientific and Technical Department.

Principal Assistant:
T. A. Henry, D.Sc. (Lond.), F.C.S.
Senior Assistants:
H. Brown.
E. Goulding, D.Sc. (Lond.), F.C.S.
Special Assistants:
H. H. Robinson, M.A. (Oxon.), F.C.S.
J. W. Evans, D.Sc. (Lond.), F.G.S.

Assistants:

A. E. Andrews (Salters' Research Fellow).
G. S. Blake, A.R.S.M.
J. W. G. Brooker, A.I.C.
S. J. Johnstone.
B. J. Eaton.
R. G. Pelly.
S. J. M. Auld, Ph.D. (Würzburg), A.I.C.
F. W. Barwick.
B. M. Jones, B.A. (Oxon.).
D. A. Bowack.
S. S. Pickles, B.Sc. (Vict.).
T. C. Thomas.
R. W. Blair, A.R.C.S.

Mineral Surveys.

Mineral Surveys of Ceylon, Southern Nigeria, and Northern Nigeria are being conducted under the supervision of the Director of the Imperial Institute by the following officers, appointed by the Colonial Office.

Ceylon: A. K. Coomaraswamy, B.Sc. (Lond.).
J. Parsons, B.Sc. (Lond.).
Southern Nigeria:
J. Parkinson, B.Sc. (Cantab.).
L. H. L. Huddart, M.A. (Cantab.), A.R.S.M., Assoc.M.Inst.C.E., Assoc.Inst.M.M.
Northern Nigeria:
J. D. Falconer, M.A., B.Sc. (Edin.).
D. R. Home.
T. Crook, A.R.C.S.

Indian and Colonial Collections.

Superintendent of Colonial Collections:
W. G. Freeman, B.Sc. (Lond.), F.L.S.
Assistants:
C. H. Nicholls, B.A. (Oxon.), F.L.S.
S. E. Chandler, D.Sc. (Lond.), F.L.S.
J. Mahon.

Superintendent of Indian Section (appointed by the India Office):
C. E. Jones, B.Sc. (Lond.), F.L.S.

BULLETIN

OF THE

IMPERIAL INSTITUTE

INDIAN AND COLONIAL COLLECTIONS.

RECENT CHANGES AND ADDITIONS.

NEW SOUTH WALES COURT.

EUCALYPTUS OILS.

(*Continued from Vol. II., page* 217.)

Class 2. *Oils less rich in Eucalyptol* (continued).

Eucalyptus rostrata, Sch. "Murray Red Gum." A widely-distributed species found on the banks of almost all the rivers of the interior of Australia. The chemical evidence points to the existence of two varieties, but distinguishing morphological characters have not as yet been observed.

The average yield of oil obtained from the leaves is 0·299 per cent. The oil consists mainly of terpenes, but contains about 10 per cent. of eucalyptol, and a quantity of aromadendral. The crude oil is red and the rectified oil yellowish in tint as is usual in eucalyptus oils containing aromadendral.

E. fastigiata, D. & M. "Cut Tail." The oil of this species consists principally of pinene, phellandrene and eudesmol. Eucalyptol is present in small amount. The crude oil is red in colour and possesses a rather unpleasant odour.

E. Dawsoni, R. T. B. "Slaty Gum." An excellent timber tree, affording large baulks of good and durable wood. The crude

oil—the average yield of which is about 0·172 per cent.—is orange-brown in colour and somewhat viscous. It is a terpene oil, phellandrene and sesquiterpene predominating.

E. macrorhynca, F. v. M. "Red Stringy-bark." This species is found in New South Wales and all the Eastern States. In addition to its timber and bark it yields an oil occasionally containing over 50 per cent. of eucalyptol.

The average yield of oil obtained by distillation of the leaves is given as 0·272 per cent. The oil is reddish-brown in colour, and its odour resembles those of the eucalyptol group. Pinene is present in small quantity, and phellandrene also occurs—in greatest amount during the early spring months. Eucalyptol is present in some quantity at certain times of the year. Eudesmol often occurs in abundance.

E. capitellata, Sm. "Brown Stringy-bark." A large tree found in New South Wales, South Australia, and Victoria. Average yield of oil 0·103 per cent., the chief constituents being terpenes, and a small amount of eucalyptol.

E. nigra, R. T. B. "Black Stringy-bark." The yield of oil is low, the average being 0·0295 per cent. Phellandrene is the principal constituent of this oil, in which not more than 5 per cent. of eucalyptol was detected.

E. pilularis, Sm. "Blackbutt." This species is one of the tallest members of the genus, and its timber is of great value for general building purposes. It occurs in Victoria and Queensland in addition to New South Wales. Phellandrene is the principal constituent of the oil which contains an alcohol, at present undetermined.

E. Planchoniana, F. v. M. "Stringy-bark." The quantity of oil obtained from this species was very small, 675 lb. of leaves yielding only 1½ ounces, or 0·014 per cent. The oil is very similar in chemical characteristics to those immediately preceding.

E. acmenoides, Sch. "White Mahogany." The species occurs in New South Wales and Queensland. The crude oil is dark orange-brown in colour, and of a very rank odour. It contains a very large amount of sesquiterpene, phellandrene is present and probably pinene. Only a minute quantity of eucalyptol was found. Average yield of oil 0·358 per cent.

E. fraxinoides, H. D. & J. H. M. "White Ash." The leaves

of this tree yield about 0·985 per cent. of a light-coloured crude oil, consisting largely of phellandrene, and about 5 per cent. of eucalyptol.

E. microtheca, F. v. M. "Coolybah" or "Tangoon." A tree widely distributed over the interior of Australia, occurring in New South Wales, South Australia, Queensland, and northern Australia. The average yield of oil was 0·150 per cent.; phellandrene occurs in quantity and traces of eucalyptol.

E. hæmastoma, Sm. "White or Scribbly Gum." The species has a wide range, and is found in New South Wales, Tasmania, Victoria, Queensland. The oil consists principally of phellandrene, sesquiterpene, with a little eucalyptol.

E. sideroxylon, A. Cunn, var. *pallens*, Benth. "Ironbark." The tree described under this name is known to occur in only one locality in New South Wales. Locally it is recognised as quite distinct from *E. sideroxylon*, the "Red Flowering Ironbark." Samples of oil of the type obtained from trees growing in widely-separated localities proved to be practically constant in composition, whilst they had little resemblance to the oil of this variety, which contains phellandrene, pinene, and eucalyptol.

E. crebra, F. v. M. "Narrow-leaved Ironbark." The most widely distributed of all the ironbarks occurring in New South Wales, Queensland, and North Australia.

Average yield of oil 0·159 per cent. The crude oil is of a light-brown colour, and contains phellandrene, pinene and a fair amount of eucalyptol.

E. siderophloia, Benth. "Broad-leaved or Red Ironbark." This species is found on the coast district from south of Port Jackson into Queensland. The yield of oil was small, 336 lb. of leaves giving only 3 ounces of oil, or 0·056 per cent. Phellandrene is the predominant constituent of the crude oil in which alcohols are also present.

E. melanophloia, F. v. M. "Silver-leaved Ironbark." A small tree found in New South Wales and Queensland. It yields a terpene oil containing phellandrene, pinene and sesquiterpene. Cymene is also present.

E. paludosa, R. T. B. "Swampy Gum." The species occurs in New South Wales, Victoria, and Tasmania. The average yield

of oil from the leaves is 0·197 per cent. The oil consists mainly of terpenes, with a small amount of eucalyptol.

E. paniculata, Sm. "White Ironbark." This species is found on the coast district and Dividing Range of South Australia, Victoria, New South Wales, and Queensland. The average yield of oil from the leaves is low, 0·088 per cent. Terpenes predominate in the oil, which contains some eucalyptol.

E. rubida, D. & M. "Candle-bark." The average yield of oil from this tree was extremely low, only 0·0084 per cent., 555 lb. of leaves only yielding ¾ ounce of oil after three distillations. Pinene is the principal constituent of a light-coloured oil, in which eucalyptol was detected in small amount.

Class 3. *Oils containing the Peppermint Ketone.*

E. piperita, Sm. The "Sydney Peppermint." This species is of especial interest, inasmuch as it was from trees of the "Sydney Peppermint," growing where Sydney itself now stands, that eucalyptus oil was first obtained, being distilled by Dr. White, Surgeon to the First Fleet in 1788. "The name of peppermint tree has been given to this plant by Mr. White on account of the very great resemblance between the essential oil drawn from its leaves and that obtained from the peppermint (*Mentha piperita*), which grows in England. This oil was found by Mr. White to be much more efficacious in removing all cholicky complaints than that of the English peppermint, which he attributes to its being less pungent and more aromatic" (White's *Journal of a voyage to New South Wales*, 1790, p. 266).

The plant is also found in Victoria and Queensland. The oil contains phellandrene, pinene, eucalyptol, and the peppermint constituent. Average yield of oil from the leaves 0·627 per cent.

E. amygdalina, Labill. "Messmate." Many other popular names are attached to this tree, which occurs in New South Wales, Australia, Victoria, and Tasmania. The average yield of oil from the leaves was very high, no less than 3·393 per cent. Phellandrene, eucalyptol, and the peppermint constituent are the principal constituents.

E. vitrea, R. T. B. "White Top Messmate." The species is found in New South Wales and Victoria. The oil contains a large amount of phellandrene, some eucalyptol, the peppermint

constituent, and probably citral. The average yield of oil is comparatively high, 1·48 per cent.

E. Luehmanniana, F. v. M. A small tree or "mallee" which is very rare in the State. The leaves yield, on the average, 0·289 per cent. of oil, in which phellandrene is the principal constituent.

E. coriacea. A. Cunn. "Cabbage Gum." This is, strictly speaking, a mountain species, extending from the New England ranges of New South Wales, into Victoria, and South Australia; it also occurs in Tasmania. The oil consists largely of phellandrene. Average yield 0·452 per cent.

E. Sieberiana, F. v. M. "Mountain Ash." This tree occurs in the Blue Mountains and coast district of New South Wales, South Australia, Victoria, and Tasmania. The oil contains much phellandrene and a somewhat large amount of the peppermint constituent. Neither eucalyptol nor eudesmol was detected.

E. oreades, R. T. B. A "Mountain Ash." The average yield of oil from this species was comparatively high, 1·16 per cent. The crude oil is colourless, has a peppermint odour, and consists largely of phellandrene.

E. dives, Sch. "Broad-leaved Peppermint." The species is common throughout the whole coastal ranges of Victoria and New South Wales. The leaves yield a large quantity of oil, 2·233 per cent., of a strong peppermint odour, and consisting largely of phellandrene; eucalyptol appears to be quite absent.

E. radiata, Sieb. "White Top Peppermint." The oil of this species is very similar in composition to that of *E. dives*. Average yield, 1·641 per cent.

E. delegatensis, R. T. B. "White Ash," "Silver-topped Mountain Ash." A very tall tree, up to 200 feet, found in New South Wales and Victoria. The average yield of oil was 1·76 per cent.; phellandrene is the principal constituent.

E. obliqua, L'Her. "Stringy-bark." This, one of the largest trees in the Australian continent, was the first eucalyptus made known to science, and on it the genus eucalyptus was founded. It occurs over extensive areas in Victoria, Queensland, and New South Wales, at high elevations, and in South Australia, and Tasmania. Phellandrene is the principal constituent of the oil, which differs from those of *E. dives*, *E. amygdalina*, etc., in having apparently aromadendral in place of the peppermint constituent.

The rectified oil is yellowish in tint, as is characteristic of aromadendral containing oils.

NEW ZEALAND COURT.

(*Continued from Vol. II., page* 151.)

ANIMAL PRODUCTS.

THE industries connected with animals and animal produce are the most important of any in New Zealand. In 1902 the value of exports, under the official heading "Animals and Produce," was £8,804,868—nearly 60 per cent. of the total exports from the Colony for the year. Wool is still the chief item of this trade, but it is closely followed by Frozen and Preserved Meat, the export of which is rapidly increasing. The third place in the exports of this class is taken by Dairy Produce, followed by that of the miscellaneous associated industries, the most important of which are fellmongering, tallow manufacture, and the preparation of sausage-skins.

In re-organising the New Zealand Court special attention has been given to the exhibition of products illustrating this group of industries.

The Wool Industry.—New Zealand is pre-eminently suitable for sheep-farming on account of its excellent pasture and mild and equable climate. Contagious disease among the stock is very rare, and all classes of sheep are stated to do well; "Merinos" thrive on the wild mountain-lands from the snow-line down to the drier portions of the plains; the "Lincoln" and "Romney Marsh" breeds flourish in the damper tracts of country, while "English" and "Border Leicesters" and "Downs" are suited to the drier hill-sides. Cross-bred sheep are now much in favour both for wool-growing and meat production, the "Merino" ewe furnishing the foundation for the many varieties now pastured.

A feature of New Zealand sheep-farming is the relatively large area of artificially-sown pastures. At the beginning of 1903 there were in the Colony over 11,808,000 acres under artificial grasses, or nearly ten times the amount of artificially-grassed land in Australia and Tasmania taken together.

In addition, winter feeding on root crops is being largely resorted to.

Shearing commences in September, and is continued until January of the following year. The staple of New Zealand wool, especially of that of "longwool" and "cross-bred" sheep, is remarkably free from "breaks" and other imperfections incidental to wool produced in countries subject to drought and scarcity of food.

In 1902–3 the export of this commodity from New Zealand was about 166,500,000 lbs., valued at nearly £4,000,000. The greater part of the export was sent to the United Kingdom.

The large exhibit of wool in the New Zealand Court has been re-arranged and displayed to better advantage. Each fleece his its shoulder and hip-locks separately mounted. A descriptive label accompanies each fleece, and gives the breed and age of the sheep, the weight of the fleece, and the locality of the run. Photographs of sheep of different breeds are also exhibited.

A series of "Bradford tops" spun from New Zealand wool has been received. Seven grades are exhibited in the Court, namely—

36's from "coarse cross-bred."
40's from "coarse cross-bred."
44's from "medium cross-bred."
50's from "half-bred."
56's from "quarter-bred."
60's from "merino" (ordinary and superior).

In recent years materials manufactured from coarser wools (viz. 36's, 40's, 44's) have been produced on a larger scale in this country than formerly, a change which has been of considerable benefit to the Colony in view of the large number of coarse-woolled animals pastured.

The Frozen and Preserved Meat Industry.—The first shipment of frozen meat from New Zealand was made in 1882, when the value of the export was £19,300. Since then the trade has grown rapidly, especially during the last ten years, and in 1903 meat to the value of over £3,300,000 was exported. Three-quarters of the export is sent to the United Kingdom, the port of London receiving the largest amount.

Sheep and lambs constitute about 80 per cent. of the exports, the most suitable breeds for the trade being known as "freezers." Animals bred from "Merino" ewes and "Longwool" rams, or from cross-bred ewes and "Downs" rams, are at present in great

favour, while "English Leicesters" and "Southdowns" furnish the so-called "prime Canterbury" mutton raised in the Middle Island.

The principal freezing works are situated at Hawke's Bay, Wellington, Canterbury, and Otago. The refrigerating plant is of modern type, the older compressed-air machinery now being replaced, to a large extent, by the newer types employing compressed ammonia or carbon-dioxide. The chief ports of shipment are Lyttelton, Wellington, Napier, and Timaru.

The preservation of meat is carried on as a collateral industry at most of the freezing works, and there are also several independent preserving factories. A great variety of goods are preserved, the greater part being tinned. In addition to supplying the local demand, considerable quantities are exported to the British and other markets. In 1903 the shipments of tinned meats amounted to 39,525 cwt. valued at £96,217: of meat extract, a comparatively new product of the Colony, there were exported in the same year 25,435 lb. valued at £3,454.

A representative collection of canned meats, prepared by the Christchurch Meat Company and the Gear Meat Preserving and Freezing Company, has been received from the Agent-General for New Zealand. The collection comprises a variety of goods, the chief being mutton, beef, brawn, tongues, soups, and dripping.

The Fisheries.—Large numbers of fish frequent the coast of New Zealand, but the fishing industry is as yet not of great dimensions. There are, however, considerable exports of canned and preserved fish, chiefly mullet, a fish which is abundant round the coasts of the Auckland district.

The rivers of the Colony are not rich in indigenous fish, but great success has attended the efforts made to introduce trout by the Acclimatisation Societies, which exist in different parts of the country. Many varieties of the Salmon family have been introduced, and the hatcheries now send out annually large quantities of ova and fry for the stocking of the rivers. The "Rainbow Trout" (*Salmo iridens*) has been found especially suitable for this purpose as the specimen in the Court, together with the photographs recently added, demonstrate.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since 20th November, 1904.

Proceedings of the Royal Geographical Society of Australasia (South Australian Branch), 1903–4	(*The Secretary.*)
Economic Zoology. 1st and 2nd Reports	By F. V. Theobald. (*The Trustees of the British Museum.*)
British Trade with South America	By P. A. Costa. (*The Author.*)
Annali del Laboratorio Chimico Centrale delle Gabelle. Vol. v., Parts 1 and 2	Edited by Dr. Vittorio Villavecchia. (*The Director.*)
Proceedings of the Royal Geographical Society of Australasia (Victoria Branch). Vols. xix., xx., xxi.	(*The Secretary.*)
Paper Mills Directory, 1905	(*The Editor.*)
Transactions of the Royal Historical Society. Vol. xviii.	(*The Secretary.*)
Lloyd's Calendar, 1905	(*The Secretary.*)
Spinning and Twisting of Long Vegetable Fibres of Commerce	By H. R. Carter. (*Messrs. C. Griffin & Co.*)
Hazell's Annual for 1905	(*Messrs. Hazell, Watson & Viney.*)
Chemical Manufacturers' Directory, 1905	(*Messrs. Simpkin, Marshall, Hamilton, Kent & Co., Ltd.*)
Daily Mail Year-book, 1905	(*The Amalgamated Press, Limited.*)

Mining Year-book, 1905 . . .	(*The Proprietors of the "Financial Times."*)
Annual Report of the Smithsonian Institution, 1903	(*The Secretary.*)
Papers and Proceedings of the Royal Society of Tasmania, 1902 . .	(*The Agent-General for Tasmania.*)
Delagoa Directory, 1905 . . .	(*Messrs. A. W. Bayly & Co.*)
Culture of Tobacco	By G. M. Odlum. (*The British South Africa Company.*)
Tea in Europe	By J. E. M. Harrington. (*The Author.*)
Records of the Cape Colony, August–December, 1825	By Dr. G. McCall Theal. (*The Hon. the Colonial Secretary.*)
British Museum Catalogues:—	
Greek Sculptures . . .	By S. H. Smith.
Terracottas	By H. B. Walters. (*The Trustees of the British Museum.*)
Lime, Mortar and Cement . . .	By W. J. Dibdin. (*The Sanitary Publishing Co.*)
Indian Textile Journal Diary, 1905 .	(*The Proprietors of the "Indian Textile Journal."*)
Australian Handbook, 1905 . .	(*Messrs. Gordon ana Gotch.*)
Dominica	By Dr. H. A. Alford Nicholls. (*Señor José Anjo.*)
Newspaper Press Directory, 1905 .	(*Messrs. C. Mitchell & Co.*)

SCIENTIFIC AND TECHNICAL DEPARTMENT.

I.—REPORTS ON RECENT INVESTIGATIONS.

The following accounts of investigations have been summarised from a selection of the Reports recently furnished to the Indian and Colonial Governments.

THE COMPOSITION AND USES OF THE VOLATILE OIL OF *BACKHOUSIA CITRIODORA* FROM QUEENSLAND.

IN September 1903 the Imperial Institute received through the Commercial Intelligence Branch of the Board of Trade an enquiry as to whether the "essential oil distilled from *Backhousia citriodora*" was obtainable in commercial quantities, and, if so, at what price.

From the results of enquiries addressed to dealers in essential oils, both in this country and abroad, it was ascertained that although this oil was known to resemble lemon-grass oil in composition and to be particularly rich in the odorous substance, citral, no considerable quantity of it had so far been placed on the market. In these circumstances it was considered advisable to draw the attention of the authorities in Queensland, where this plant is stated to be widely distributed, to the value of the oil and to the possibility of using it as a source of citral for which there is at present a considerable demand.

A communication upon the subject was therefore forwarded to the Queensland Department of Agriculture asking whether the preparation of this oil from the plant could be undertaken there. This request elicited the following information :—

"*Backhousia citriodora* is plentiful on the coast between Brisbane and Gympie, but the distillation of essential oils is an industry that is not yet followed in Queensland. No price for this oil can therefore be stated, but if you can supply particulars of the value of it in London and the probable quantities that will

be required, the information given will be circulated with the hope that the inducement offered may encourage the distillation of essential oils in commercial quantities."

As it was impossible to say exactly what the commercial value of this oil might be, and what demand there would be for it in commerce, it was suggested that a small quantity of the oil should be distilled in Queensland, and forwarded to the Imperial Institute for examination and commercial valuation. In compliance with this request a sample of the Queensland oil was sent to the Imperial Institute and has been examined in the Scientific and Technical Department.

Chemical Examination.

The sample of the oil of *Backhousia citriodora* received consisted of a greenish-yellow liquid, which was slightly turbid owing to the presence of a small quantity of water; the latter readily settled out on standing, leaving a bright transparent oil. It had a strong odour of citral.

The oil was miscible with 80 per cent. alcohol in all proportions and was completely soluble in 2·25 times its own volume of 70 per cent. alcohol. On distillation 100 cc. of the oil gave the following fractions:—

Boiling from 212° to 219° C.	10 cc.	(including 1 cc. of water).
,, ,, 219° to 226° C.	70 cc.	These two fractions consisted principally of citral, which boils at 224° to 228°.
,, ,, 226° to 231° C.	10 cc.	
Residue and loss	10 cc.	

The crude oil had the following physical constants:—

Specific gravity at 21°	0·8903
Refractive index at 22°	1·4940
Optical rotation in a 100 mm. tube .	nil

The amount of citral in the oil was determined by the bisulphite process and found to be 93·5 per cent.

These results show that this oil is one of the richest known sources of the odorous substance, citral, containing as it does 93·5 per cent. of this constituent, whereas East Indian lemon-

grass oil, which is at present the principal source of citral, contains only from 70 to 80 per cent. of this material.

The analytical results quoted above agree fairly well with those recorded for a specimen of the oil of *Backhousia citriodora* examined in 1888 (*Schimmel's Berichte*, 1888, Part I., page 20), which was stated to have the specific gravity 0·900 and to consist largely of citral. The concordance between the results found for the two samples of oil examined in 1888 and for that now examined indicates that the richness of this oil in citral is a characteristic and constant feature.

Commercial Valuation.

Small samples of the oil were submitted for commercial valuation to two firms dealing in volatile oils, who were informed of the results of the chemical examination.

One of these firms stated that the oil would be worth as much as pure lemon-grass oil, viz. about *7d.* per ounce c. i. f. London, whilst the other was of opinion that it would be saleable in the London market at *9d.* to 9½*d.* per ounce. If oil containing as high a percentage of citral as the present sample can be regularly placed on the market, it is probable that the higher price mentioned above could be secured.

Some idea of the extent of the demand for oils containing citral may be obtained from the following figures showing the export of lemon-grass oil from the Malabar coast of India, which is at present the principal centre of production.

Year.	Cases.
1900–01	1,933
1901–02	2,322
1902–03	2,807

Each case contains approximately two gallons of oil.

In addition about 200 gallons of this oil are produced yearly in the Straits Settlements.

In view of these facts it appears to be well worth consideration in Queensland whether the distillation of the oil of *Backhousia citriodora* upon a commercial scale could not be undertaken in that colony.

"MUTEKE" RUBBER FROM NORTH-EASTERN RHODESIA.

THIS sample of rubber, together with specimens of the leaves, flowers, and fruits of the plant yielding it, were forwarded to the Imperial Institute by the British South Africa Company. The specimens were accompanied by a letter requesting that the rubber should be chemically examined in the Scientific and Technical Department of the Imperial Institute, and information as to its commercial value obtained. With the letter was enclosed a memorandum, forwarded by the Administrator of North-Eastern Rhodesia, containing some observations, by the Native Commissioner of the Abercorn Division, on the plant yielding this rubber and the method of preparing the latter. The information supplied is as follows:—

"The 'Muteke' or 'Mutecha' plant yielding this rubber is a large creeper, having a small bright-green leaf with a highly-glazed finish on the top, but dull underneath. The berry is about the size of a small plum. As far as I can discover, the natives are not aware that rubber can be extracted from the root and branch (stem) of this plant. The berry when plucked exudes a white milky fluid which is not rubber. On cutting the bark from the stem and making an incision, the rubber flows in a liquid form. This, on being spread over the arms and chest, takes a solid form, and can then be rolled into a ball in the usual manner. From what I have seen I should say that the stem contains more rubber than the root. The larger specimen of rubber sent is from the branch, the small ball is mixed root and stem. The creeper, which grows to a large size (about a foot in circumference), is said to be common all over the Abercorn Division."

Botanical Source of the Rubber.

The specimens of leaves, flowers, and fruits of the vine yielding this rubber which were transmitted with it from Rhodesia were submitted to the Director of the Royal Botanic Gardens, Kew, for identification. He reported that the specimens were not in sufficiently good condition to permit of an

exact determination of the species being made, but that probably the "Muteke" plant would prove to be an entirely new species of *Landolphia*.

Description of Sample.

The sample of rubber consisted of two small balls weighing 4·5 and 1·5 grams respectively, the former being derived from a large branch and the latter partly from root and partly from stem. The two balls were not markedly different in appearance or properties, and in both the rubber was dark reddish-brown in colour, quite dry and free from stickiness, and contained very little foreign vegetable matter. It exhibited good elasticity and tenacity, and dissolved almost completely in benzene, chloroform, and carbon disulphide, and partially in ether.

Chemical Examination.

It would have been desirable to submit both samples of rubber to chemical examination, but the specimen obtained from root and stem was too small for this purpose, and consequently only the larger ball was analysed. It gave the following results :—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	4·6	—
Resin	12·0	12·5
Caoutchouc	79·7	83·6
Dirt and insoluble matter	3·7	3·9
Ash (included in "Dirt and insoluble matter")	0·4	0·5

These results show that this rubber is of fair quality. The amount of resin present is rather higher than is desirable, but the moisture is low, and the true caoutchouc reaches the fairly high figure of 83·6 per cent. in the dry material.

Commercial Valuation.

The quantity of the material available was insufficient to permit of samples being sent to brokers for valuation, and consequently the exact commercial value of the rubber cannot be stated, but it is probable that it would fetch at the present time about 3*s*. per pound.

The foregoing results, though somewhat inconclusive owing to the smallness and unsatisfactory character of the specimens sent for examination, are sufficient to indicate that this rubber is of fair quality and likely to be of considerable commercial value.

In order that its exact value may be ascertained, a further sample of at least two pounds of the rubber should be collected and forwarded to the Imperial Institute for chemical examination. The sample should be accompanied by carefully prepared botanical specimens showing the leaves, flowers, and fruits of the "Muteke" plant from which the rubber is obtained. With this further supply of material it will be possible to ascertain precisely the nature, commercial value, and possibilities of the rubber, and also its botanical source.

"DANDE" RUBBER FROM RHODESIA.

AT the instance of the British South Africa Company the Scientific and Technical Department of the Imperial Institute has examined during the last two years a number of products, allied to rubber and gutta percha, which have been forwarded from Rhodesia for the purpose of ascertaining whether any of them were likely to be of commercial value. Among the earliest specimens submitted was a small sample of genuine rubber, which was forwarded from the Umtali District, and was stated to be obtained from a plant known locally as "Dande." The rubber, which had been collected upon a twig, was dark brown in colour, rather soft and sticky, and somewhat deficient in tenacity. An analysis gave the following figures:—

Moisture	1·2 per cent.
Resin	7·0 "
Caoutchouc	88·3 "
Dirt and insoluble matter	3·5 "
Ash (included in "Dirt")	1·7 per cent.

These results indicated that so far as chemical composition was concerned the rubber was of very fair quality, and would

be readily saleable in the market, especially if better prepared so as to avoid the stickiness shown by the specimen submitted.

A larger sample of the rubber and botanical specimens of the plant yielding it were accordingly requested, so that the quality and value of the rubber could be definitely ascertained and its botanical source determined. These specimens have now been received, and their examination has furnished the following results.

The second sample of the "Dande" rubber from the Umtali District consisted of a single ball, about two and a half inches in diameter, and weighing 155 grams, which had evidently been formed by winding threads of rubber upon a central mass. The ball was light reddish-brown externally, but when cut it was found to be white at the centre and rather moist. The rubber exhibited very good physical properties.

Its composition as determined by chemical examination was as follows:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	15·5	—
Caoutchouc	68·1	80·7
Resin	10·7	12·6
Dirt and insoluble matter	5·7	6·7
Ash (included in "Dirt")	1·6	1·9

The rubber was therefore of very fair quality, containing 80·7 per cent. of caoutchouc and 12·6 per cent. of resin in the dry material. It was not equal in chemical composition to the small sample previously examined, which contained 88 per cent. of caoutchouc and only 7 per cent. of resin, but it was much superior in physical characters.

The rubber was submitted for valuation to brokers, who reported that consignments of similar quality would fetch about 3*s.* 6*d.* per lb. in the London market, the current quotation for Para rubber being 4*s.* 9*d.* per lb. at the time.

It seems clear from these results that this plant yields marketable rubber of good quality, and, if abundant in Rhodesia, it should prove a valuable source of that material.

Botanical Source of "DANDE" Rubber.

The botanical specimens of the "Dande" plant were forwarded to the Royal Botanic Gardens, Kew, for identification. It proves to be a species of *Landolphia* closely resembling *Landolphia petersiana*, Dyer, but its exact identity could not be determined, as the specimens did not show the flowers or fruits of the plant in a sufficiently well-developed condition.

It would be of great interest to ascertain the identity of the "Dande" plant, and it has been suggested that further botanical specimens, showing fully-developed flowers and fruits, should be forwarded to the Imperial Institute so that this point may be determined.

WORKING QUALITIES OF TIMBERS FROM THE BRITISH CENTRAL AFRICA PROTECTORATE.

THESE specimens of timber were collected in British Central Africa by Captain Claud Percival, and were forwarded by him in December 1903 to the Royal Botanic Gardens, Kew. As the Director of Kew Gardens considered it advisable that the working qualities of these woods should be ascertained, the specimens were sent to the Imperial Institute for this purpose, together with a memorandum from Captain Percival giving the names of the timbers in the Yao language, and some particulars regarding the localities in which the various woods were collected and the uses to which they are applied in the Protectorate. The salient points of this information are embodied in the following paragraphs, detailing the results obtained in working the various woods.

As the specimens were very small, measuring as a rule only $12 \times 8 \times 1$ cubic inches, it was impossible to carry out a series of mechanical tests to determine their strengths. They were therefore referred to Mr. Herbert Stone of Birmingham, who

very kindly undertook to examine them and to report upon their working qualities. Mr. Stone's report is as follows:—

Specimen No. 1 *a*.—"*Mlupati*," described as obtained from an old tree on Mangoche Mountain. These trees occur between 3,000 and 5,000 feet above sea-level. "A fine-grained, compact, solid, yet not heavy wood, which works very easily and well. It has the appearance of American Red Gum (Satin Walnut). Locally useful, but not of sufficient value for export. It is apparently subject to the attacks of insects, as the specimen is perforated with the galleries of a small borer.

Weight, 44 lb. per cubic foot.
Hardness about equal to beech.
Polishes well with little trouble."

Specimen No. 1 *b*.—"Described as obtained from a young '*Mlupati*' tree in the same locality as Specimen No. 1 *a*, but it differs entirely in structure, and belongs to another genus, if not to another order. It is a much superior wood, being more compact, much heavier, tougher, and of better colour. It presents some resemblance to steamed beech without the figure of that wood. It works well, though hard. It evidently warps badly, and the specimen shows similar worm-galleries to those in Specimen No. 1 *a*.

Weight, 56¾ lb. per cubic foot.
Hardness equal to beech.
Polishes fairly well, but takes rather a long time to produce a good surface."

Specimen No. 2.—"*Mlilila*," occurring under the same conditions as Specimen No. 1, and like it collected on Mangoche Mountain. "This is a fine-grained wood, strongly resembling American birch, and of similar solidity and hardness. The specimen has the appearance of being slightly unsound, and has similar worm-galleries to the preceding samples. It appears to have little tendency to warp. From the structure it appears to be allied to No. 1 *a*.

Weight, 45 lb. per cubic foot.
Hardness equal to American birch.
Polishes well with little trouble. A nice mellow wood to work."

Specimen No. 3.—"*Nakawalika*." Mangoche district, "on

hill-tops at 6,000 feet." "An inferior wood that warps badly, and evidently lacks durability, as shown by the decay surrounding the worm-galleries caused by a rather larger species of borer than that which attacks the three preceding woods. It is hard, heavy, and compact, and has some resemblance to inferior ash, but is much finer in the grain. It is probably allied to Nos. 1 *a* and 2. Though of no value for export, it may yet prove serviceable locally for rough carpentry when better sorts are not obtainable. Crisp and hard to work.

Weight, 53 lb. per cubic foot.

Hardness equal to hornbeam.

Polishes very well; a good surface is produced rapidly."

Specimen No. 4.—"*Mkuguza*," or "*Mlanje Cedar*," from the Mlanje Mountain, "at 6,000 feet and over." This tree does not occur in the Mangoche district. "A very light, mellow, and firm, but not very soft wood of a uniform reddish colour, and surface having a frosted lustre. In radial section the figure is rather pretty, recalling Kauri Pine. It works as easily and as well as deal, and is what may be called an excellent deal-substitute. There appears to be a slight tendency to warp, but this may be due to the manner of preparation of the specimen; and as this wood is reputed to be proof against white ants and other insects, its local value must be considerable.

Weight, 38¼ lb. per cubic foot.

Hardness equal to Kauri pine.

Polishes well with little trouble."

Specimen No. 5 *a*.—"*Mkalati*." Mangoche district. "Solitary trees on the open plain up to 3,500 feet above sea-level." "This wood displays a very handsome figure, no matter in which direction it may be cut. It is heavy, hard, and compact. It has a very strong resemblance to the Beukenhout or so-called Cape beech, or to very finely-figured English beech. On account of its hardness it is rather difficult to work, added to which it is rather brittle and fissile; but it finishes excellently, and would make first-class ornamental work, such as marquetry. It might be worth 3*s*. to 4*s*. per cubic foot in England.

Weight 48¾ lb. per cubic foot.

Hardness equal to hornbeam.

Polishes without trouble."

Specimen No. 5 *b*.—"This is a second sample of '*Mkalati*,' showing a portion of the sapwood, which, singularly enough, is darker than the heartwood—a circumstance of rare occurrence. This specimen is considerably harder and heavier than No. 5*a*.

Weight 53½ lb. per cubic foot.

Hardness equal to boxwood.

Polishes well with little trouble."

Specimen No. 6.—"*Mbowwa*." This occurs on streams or near water up to 3,500 feet above sea-level in the Mangoche district. "A species of *Cedrela* strongly resembling Mexican Cedar, but if anything possessing a finer lustre. It is soft and fissile; a good and easy wood to work, and takes a fine finish. It would be readily accepted as a substitute for Mexican cedar or for the cheaper qualities of mahogany or baywood. As the tree grows on the banks of streams, and can possibly be transported to the coast without great cost, it might be worth while trying to export the timber. It shares with other species of *Cedrela* the property of being obnoxious to insects and white ants.

Weight 36½ lb. per cubic foot.

Hardness equal to English birch.

Polishes well with little trouble."

Specimen No. 7 *a*.—"*Mlombwa*," or "*Mtumbati*" (Bastard Mahogany?). This tree occurs in forest country or woodland up to 3,500 feet above sea-level in the Mangoche district. "This specimen is from an old tree, and is a leguminous wood allied to that of *Pterocarpus*. It has a superficial resemblance to walnut, being of a uniform warm walnut colour, with a coarse open grain. It is very hard, brittle, rather cross-grained, and by no means easy to work. Being a handsome wood it may be worth a trial for export, but the experiment will be of the nature of a speculation.

Weight 51 lb. per cubic foot.

Hardness equal to boxwood.

Polishes well with little trouble. The colour comes out on to the 'rubber,' and the wood becomes lighter in colour during the process."

Specimen No. 7 *b*.—Specimen of "*Mlombwa*" derived from a

young tree. "This is a very rough, cross-grained piece, of much inferior colour.

Weight 56½ lb. per cubic foot."

Specimen No. 8.—"*Mazuka.*" Occurs in the forests and woods of the Mangoche district up to 5,000 feet above sea-level. Above 4,000 feet it becomes small. "A wood of pleasing appearance resembling American birch, but of a deeper reddish colour and more figure. It is of medium weight, fine in the grain and compact, and is no doubt a useful wood in the locality in which it is grown, as it is reputed to resist insects and white ants. It works without difficulty. The specimen is badly split and warped.

Weight 40¼ lb. per cubic foot.

Hardness equal to English birch.

Polishes well with little trouble."

Specimen No. 9.—"*Mchenga.*" Occurs in the forests in Mangoche, probably always below 3,500 feet. This specimen is from a young tree. "A very rough specimen, from which it would be difficult to form an opinion of the timber. The wood is of a whitish-brown colour, has no ornamental value, is difficult to work, but planes very cleanly even across the grain. Though firm, tough, and compact, it has a doubtful appearance. Larger trees may yield better samples.

Weight 52 lb. per cubic foot.

Hardness equal to hornbeam.

Polishes well without trouble, but is not worth it."

"DENJI" AND "NZONOGWI" FIBRES FROM BRITISH CENTRAL AFRICA.

THESE samples of fibre were forwarded to the Imperial Institute by the Scientific Department, Zomba, British Central Africa, at the direction of H.M. Commissioner, and were accompanied by a letter in which it was stated that the fibres are derived from plants known to the natives as "Denji" and "Nzonogwi." Both plants are stated to grow abundantly in the neighbourhood of Zomba and throughout the Shiré Highlands, and generally to occur in marshy places. "Nzonogwi" attains its greatest height on any marshy soil, whilst "Denji" grows well in the good, rich, deep soil of the slopes of Zomba. The fibre is said to have been prepared in the following manner:—

The stems are cut close to the ground, and scraped with a knife in order to remove the smaller branches and the rough, hairy epidermis. The bark is readily stripped from the stems, and the ribbons so obtained have an average length of 5½ feet. After these ribbons have been immersed in water for fourteen days, the fibre is easily separated from the pulp, is cleaned by washing, and afterwards dried by exposure to the sun for twenty-four to forty-eight hours.

Botanical specimens of the plants including flowers, leaves, and seeds were forwarded by the Scientific Department, Zomba, to the Royal Botanic Gardens, Kew, with the result that "Denji" was identified as *Sida rhombifolia*, L., and "Nzonogwi" as *Triumfetta rhomboidea*, L.

The samples of fibre have been examined in the Scientific and Technical Department of the Imperial Institute with the following results:—

Fibre of *Sida rhombifolia* ("Denji" fibre).

This sample consisted of about 1¼ lb. of prepared fibre and ½ lb. of dried ribbons of bark, the latter being about 5 feet long.

The prepared fibre was partly greyish and partly of a pale buff colour. It was fairly well cleaned, and had a length of 4½–5 feet. The results of its chemical examination are given below, together with those of two Indian specimens of this fibre and of a sample of Indian jute of "extra fine quality" which have been examined in the Scientific and Technical Department of the Imperial Institute.

	Sida rhombifolia			"Extra fine" Indian jute.
	from B. C. A. "Denji."	from Rahuta, Bengal.	from Rajshahi, Bengal.	
Moisture per cent.	10·3	12·7	12·7	9·6
Ash ,,	1·0	1·6	1·4	0·7
α-Hydrolysis, loss per cent.	8·5	8·7	11·2	9·1
β-Hydrolysis, ,, ,,	13·5	14·5	14·8	13·1
Mercerisation, ,, ,,	7·5	13·2	10·3	8·5
Acid purification, loss per cent.	1·8	1·9	3·3	2·0
Nitration, gain per cent.	23·6	32·2	27·0	36·7
Cellulose, per cent.	77·4	79·3	76·2	77·7
Length of ultimate fibre.	1·7–3·0 mm. or 0·07–0·12 in.	2·0–2·5 mm. or 0·08–0·10 in.	1·5–2·6 mm. or 0·06–0·10 in.	1·5–3·0 mm. or 0·06–0·12 in.

On comparing these figures it is evident that the quality of the present specimen is not inferior to that of the Indian samples, and in some respects it is, in fact, superior, notably in the greater resistance of the fibre to the action of alkali as indicated by the results of the hydrolysis and mercerisation. It is also evident that this material resembles jute in its chemical behaviour and composition, and also in the length of its ultimate fibres.

Fibre of *Triumfetta rhomboidea* ("Nzonogwi" fibre).

This sample consisted of about 1½ lb. of prepared fibre and ½ lb. of the dried bark in ribbons of a length of 4½–5 feet.

The prepared fibre resembled that of the "Denji" plant in general character and appearance. It was imperfectly cleaned, and from 4½–5 feet long. On chemical examination it yielded the following results, to which are added for comparison those given by a sample of Indian jute of "extra fine" quality.

	Triumfetta rhomboidea (" Nzonogwi").	" Extra fine " Indian jute.
Moisture, per cent.	10·4	9·6
Ash, per cent.	0·6	0·7
α-Hydrolysis, loss per cent.	9·1	9·1
β-Hydrolysis, ,, ,,	14·7	13·1
Mercerisation, ,, ,,	8·5	8·5
Acid purification, loss per cent.	3·4	2·0
Nitration, gain per cent.	30·2	36·7
Cellulose, per cent.	76·2	77·7
Length of ultimate fibre	2·0–2·8 mm. or 0·08–0·11 in.	1·5–3·0 mm. or 0·06–0·12 in.

These results show that this fibre is of good quality, and closely resembles jute in its chemical characteristics and composition, as well as in the length of its ultimate fibres.

Representative specimens of " Denji " and " Nzonogwi " fibres have been submitted to fibre experts and brokers for commercial valuation. They report that the products are similar in character, and both consist of soft, fine bast fibre. The strength is mixed—a small portion of each being fairly strong, but the greater part weak. The fibres are probably inferior to jute in spinning qualities, and are apparently only suitable for tow yarns. The brokers state that the value of the fibres is approximately £12 per ton, but that a higher price might be obtained if they were found to give good results when worked with machinery. It is considered desirable that a larger quantity of the fibres should be examined with special reference to their behaviour in spinning and other manufacturing processes, and it is suggested that a ton or two of each fibre, as clean as possible, should be sent for this purpose. Full particulars should be furnished as to the possibilities of supply, and the price at which the fibres could be delivered in London, in order that manufacturers may be induced to make trials of these products.

From the foregoing reports it appears that these fibres, if carefully prepared, might prove to be of commercial value if constant supplies could be assured. It has, however, to be remembered that these fibres would have to compete with jute, which has already a regular and well-established market.

THE EXAMINATION OF COTTON GROWN IN THE SOUTH AFRICAN COLONIES.

IN connection with the efforts which are being made to promote cotton growing in the various British Colonies and Dependencies, a number of samples have been forwarded to the Imperial Institute from the South African Colonies. The object of the present article is to give an account of the results of the examination of these samples, and to indicate, so far as possible, the extent to which South Africa is adapted for cotton growing, and the prospects of the cultivation in its different Colonies.

THE TRANSVAAL.

A variety of *Gossypium herbaceum* grows wild in the low country of the Transvaal, and is cultivated by the natives in the Northern and Eastern Districts. The extension of cotton growing is under the consideration of the Transvaal Department of Agriculture, and experiments are being carried out with the object of testing the suitability of the climate and the possibility of obtaining remunerative crops of both native and exotic varieties. Samples of American, Egyptian, and Indian cotton seed have been distributed to the farmers for carrying out trials on small plots. The labour question offers some difficulty to the establishment of a cotton industry, but this side of the matter is receiving careful attention.

Samples of six different kinds of cotton have been forwarded to the Imperial Institute by the Transvaal Department of Agriculture, and have been examined in the Scientific and Technical Department, and submitted to commercial experts for valuation. The following is a summary of the reports of these investigations :—

No. 473/04.—This sample of cotton was grown at Malelane, Eastern Transvaal. It is stated that this cotton is not indigenous to the Transvaal, but grows wild in several of the warmer parts of the Colony.

The sample consisted of unginned cotton, the fibre of which was very firmly attached to the seed, the latter being exceptionally small and closely invested with short, downy hairs. The

fibre was nearly white except for occasional buff-coloured stains; its staple was harsh, coarse, and short, the length varying from 0·6 to one inch.

A small quantity of the fibre was carefully removed from the seed by hand, and together with a portion of the original sample, was submitted to a firm of brokers for commercial valuation. The former was reported to be worth 5*d.* per lb., whilst the unginned cotton was said to have a probable value of ¾*d.* to 1*d.* per lb., "Middling American" cotton being quoted on the same date at 6¾*d.* per lb.

No. 477/04.—This and the four following samples of cotton were grown in the Zoutpansberg District. This cotton was cream-coloured, harsh to the touch, of good strength, and from 1·0 to 1·2 inches long. The brokers reported that the material was clean, of good colour, and short, rough staple. Value about 5*d.* per lb. (29th October, 1904), "Middling American" being quoted at 5·3*d.* per lb.

No. 478/04.—This sample of ginned cotton was harsh to the touch, and of a pale reddish-brown colour with occasional darker stains. The greater proportion of the fibres were 1·3 to 1·5 inches long; but a small quantity of the cotton, especially that of a paler colour or nearly white, had a length of only 1·0 to 1·2 inches. The brokers valued this product at about 4½*d.* per lb. (29th October, 1904).

No. 479/04.—This sample of ginned cotton was of a pale buff colour, but contained occasional white portions. The fibre was of irregular length, varying from 0·9 to 1·4 inches. The brokers stated that the material was worth 5*d.* per lb. (29th October, 1904).

No. 567/04.—This sample was grown on the Eastern slope of the Woodbush Mountain, Zoutpansberg District. It consisted of about a quarter of an ounce of cotton which had been ginned, but still contained a few seeds, which were smooth and black, and bore a tuft of short, greenish hairs. The cotton was cream-coloured, soft to the touch, and 1·4 to 1·6 inches long.

The brokers reported that the staple was long and strong but lacking in silkiness, and that the product was of a high grade, and worth about 7½*d.* per lb. (29th October, 1904).

Since, on the date of this valuation, "Middling American"

cotton was quoted on the Liverpool market at 5·30*d.* per lb., it is evident that this Transvaal cotton is of excellent quality.

No. 725/04.—This sample was labelled, "Native Cotton from Mr. Reid, Zoutpansberg," and consisted of about four ounces of ginned cotton. A few seeds which still remained in the sample were of a dark brown colour, slighty downy, and bore a pale brown tuft at the pointed end. The cotton was of a pale reddish-brown colour, rather coarse, and of irregular length, varying from 0·9 to 1·4 inches. The brokers reported that the material was of rough, short staple and only suitable for "cotton-waste spinning." Its value was estimated at about 3¾*d.* per lb. (29th October, 1904).

There can be no doubt that the quality of all these cottons could be improved by careful methods of cultivation. The irregularities occurring in the staple, which are particularly marked in Nos. 478/04 and 479/04, could doubtless be remedied by a process of seed selection, and in this way the value of the cotton would be enhanced to a considerable extent.

Another sample of cotton, collected from wild plants in the Zoutpansberg District, was submitted to the Imperial Institute by the Secretary of the Central South African Lands and Mines, Limited, who stated that there are large areas of good arable land in the Zoutpansberg District possessing an abundant underground supply of water, which could be brought to the surface for purposes of irrigation.

The sample consisted of unginned cotton, and contained numerous fragments of leaves and bolls. The seeds varied in colour from light brown to dark brown, and were slightly downy. The cotton was white with occasional buff-coloured patches, was fairly soft to the touch, of good strength, and 1·0 to 1·3 inches long.

The commercial experts reported that the fibre was of a character similar to that of rough Peruvian cotton, and that the ginned material was worth 5·70*d.* per lb. (29th October, 1904).

In connection with the cottons of the Transvaal, reference may be made to a curious sample of a so-called "wild cotton" from this Colony, which was forwarded to the Imperial Institute in June 1904, by the Secretary of the British Cotton Growing

Association, with a request that it might be submitted to examination.

The "cotton" was very harsh and coarse, extremely weak and brittle, of a semi-transparent appearance, and 1·0 to 1·2 inches long. On examination with the microscope, the fibre was seen to consist of a hollow, comparatively thin-walled tube, which did not possess the twisted appearance characteristic of true cotton fibre, and was much wider than the latter.

The difference between this material and ordinary cotton was also shown in its chemical composition. The percentage of cellulose in the fibre was found to amount to only 77·3 per cent., whereas true cotton usually contains from 95 to 96·5 per cent.

The seeds were small, smooth, of a pale brown colour, and triangular shape.

Since this examination showed that the characters of both the fibre and seed were widely different from those of ordinary cotton, it was considered of interest to ascertain the botanical source of the material. A representative specimen was therefore submitted to the Director of the Royal Gardens, Kew, and was identified as the product of *Ipomœa albivenia*, G. Don. This fibre, therefore, is not derived from the true cotton (*Gossypium species*), but from an entirely distinct plant.

There can be no doubt that this product would be of little value for spinning purposes, but it is possible that it might find an application as a filling material in upholstery.

It will be seen from this account of cotton growing in the Transvaal, that the cultivation has not yet advanced beyond the experimental stage, but that, on the whole, the prospects appear to be very favourable if an adequate and sufficiently cheap labour supply can be obtained. It is probable that better results would be secured by devoting careful attention to the superior kinds of native cotton than by the introduction of exotic varieties, although experiments with the latter should not be excluded.

SWAZILAND.

The suitability of Swaziland for cotton growing is being studied, and it is hoped that ere long planting will be undertaken

on a commercial scale. It has been stated recently in the *Times of Swaziland*, that the Swaziland Corporation has started an experiment station on the Mawelawela Island in the Usutu River, and that trials are being made with Sea Island, Upland, Egyptian, Indian, Brazilian, and native seed. One of the principal objects in view is to improve the native cotton, which even in the wild state is of good strength and lustre.

ORANGE RIVER COLONY.

So far as can be ascertained, cotton has never been grown in the Orange River Colony, and it is considered doubtful whether its cultivation would succeed. The question is now under the consideration of the local Government.

CAPE COLONY.

The following information relating to the prospects of cotton growing in Cape Colony has been supplied to the Imperial Institute by the Department of Agriculture, Cape Town.

Many attempts have been made to establish cotton growing in Cape Colony, but without success. The climate is too dry and too liable to sudden hygrometric changes for the finer kinds of cotton, but it is well adapted to short-stapled forms such as those of India. The cultivation of cotton on a commercial scale in this Colony is, however, quite impossible at present for two reasons, namely, the scarcity and dearness of labour and the lack of cheap shipping facilities to Europe.

NATAL.

Cotton was grown in Natal about thirty years ago, and consignments of the product were sold in the Liverpool market at the same price as the best samples of American Upland cotton. Specimens of cotton, described as "Sea Island cotton grown in Natal," were shown at the Indian and Colonial Exhibition of 1886, and were stated to be of good quality.

There is no cotton industry in Natal at the present time, but experiments are in progress, and the Government are offering land in Zululand on nominal terms for the purpose of trials.

Experimental planting is being carried on by a Syndicate of Natal farmers as well as by individual Colonists.

Two samples of cotton and some specimens of the plant from which they were derived, were forwarded to the Imperial Institute in October 1904, by the Agent-General for Natal, with a request for a report on the value of the cotton and the identification of the plant.

The botanical specimens were transmitted to the Royal Botanic Gardens, Kew, where the plant was identified as *Gossypium brasiliense*, the "kidney cotton" of commerce.

The samples of cotton were examined in the Scientific and Technical Department of the Imperial Institute, and specimens of the lint, carefully removed from the seeds, were submitted to brokers for commercial valuation.

Sample labelled: "1. Sample of Cotton grown at Mount Vernon, Hillarys, from W. W. Cato."

This sample consisted of about three ounces of unginned cotton. The seeds were attached to one another in rather long oval groups (from the appearance of which the product is termed, "kidney cotton"), and were of a dark brown colour. The surface of the seeds was generally smooth, but in some cases was more or less coated with short green or greenish-brown hairs.

The cotton was nearly white with occasional buff-coloured patches. It was rather harsh to the touch, crinkly, of good strength and somewhat irregular length, varying from 1·0 to 1·4 inches. The brokers reported that the fibre resembled rough Peruvian cotton, and valued the ginned material at about 5·80*d.* per lb. (29th October, 1904).

Sample labelled: "2. Sample of Cotton grown at Hillarys, from W. W. Cato."

This sample consisted of about three ounces of unginned cotton. The seeds were not so firmly attached to one another as were those of Sample 1, but still showed a tendency to cling together; they were black and somewhat downy.

The cotton was mostly of a pale buff colour, but a small proportion was white. The fibre was fairly soft to the touch, crinkly, strong, and 1·2 to 1·4 inches long. The brokers reported that the product was similar to Brazilian or rough Peruvian

cotton, and that the ginned material was worth about 5·90*d.* per lb. (29th October, 1904).

It is evident from the foregoing report that these cottons are of good quality, and would no doubt repay cultivation. The products are of greater value than "Middling American" cotton which, on the date that the above valuations were given, was quoted in the Liverpool market at 5·30*d.* per lb.

PETROLEUM FROM THE MAYARO-GUAYAGUAYARE DISTRICT, TRINIDAD.

In October 1903 the Imperial Institute furnished to the Government of Trinidad a report on two samples of crude petroleum, from the district of Mayaro-Guayaguayare on the south-east side of the island, which had been forwarded for chemical examination.

In June 1904 a further consignment of samples of petroleum from the same district was forwarded to the Imperial Institute, with the request that analyses might be made and the results communicated to the Government of Trinidad.

The covering letter gave no precise information regarding the origin of the samples, but there is reason to believe that those numbered 1, 2, 3, and 4 respectively represent oils from the wells numbered 1, 2, 3, and 4 in Mr. Cunningham Craig's report on the petroleum districts of Trinidad and the map and sections which illustrate it; while there can be little doubt that the sample marked L. S. came from the oil-spring at Lizard Spring, a small creek which flows into the Lizard River from the north.

Sample A of the first consignment was also obtained from No. 1 well, while Sample B was, it appears from Mr. Cunningham Craig's report, from Lizard Spring.

Description and Chemical Examination of Samples.

The samples were examined in the Scientific and Technical Department of the Imperial Institute, and gave the results stated below. The flash points given were in each case determined by the Abel-Pensky method.

Sample No. 1.—Freshly-drawn oil from No. 1 well, situated near Pilot River. This is a black opaque oil with a specific gravity of 0·894 at 17° C., at which temperature it is completely fluid. Its flash point is 2° C. (35·6° F.). The results of its fractional distillation and the nature of the products obtained are shown in the following table:—

SAMPLE NO. 1.

Temperature at which distilled.	Fractions expressed as volume percentages.	Specific Gravity of fractions.	Remarks.
17° to 120° C.	10 per cent.	0·762	These three fractions constitute the "light petroleum," of which 23 per cent. is present. This material absorbed 1·15 per cent. of its weight of bromine, and had a flash point—1° C.
120° to 140° C.	9·4 "	0·798	
140° to 150° C.	3·6 "	0 816	
150° to 180° C.	6·0 "	0·832	These four portions together form "kerosene," of which 39·5 per cent. was obtained; it absorbed 7·65 per cent. of its weight of bromine and "flashed" at 48·5° C.
180° to 210° C.	8·0 "	0·848	
210° to 245° C.	8·5 "	0·878	
245° to 292° C.	17·0 "	0·906	
Above 300°	26·0 "	0·929	The portion boiling above 300° C. forms "heavy oil," of which 33 per cent. was obtained. It absorbed 34·5 per cent. of its weight of bromine.
Under reduced pressure	7·0 "	0·921	
Coke and loss	4·5 "		

In the analysis of the previous sample (A) from this well there were found 11·1 per cent. of light petroleum, 38 per cent. of kerosene or burning oil, 43 per cent. of heavy oil, and 7·9 of coke. The increased percentages of light petroleum and kerosene in the present sample are no doubt due to the fact that the lighter

constituents had not had time to evaporate when the present specimen was collected.

In the high percentage of lubricating oil the oil from No. 1 well approaches some of the Russian oils. The amount of bromine absorbed by the heavy oil from this well is very high.

Sample No. 2.—From No. 2 well, situated one mile south-west of No. 1 well. This oil is dark brown in colour and practically opaque. Its specific gravity is 0·913 and the flash point 9° C. (48·2° F.). It is quite liquid but rather viscous. The results of its fractional distillation are as follows :—

SAMPLE NO. 2.

Temperature at which distilled.	Fractions expressed as volume percentages.	Specific Gravity of fractions.	Remarks.
to 150° C.	12·0 per cent.	0·771	Equal to "light petroleum" 12 per cent. This absorbed 1·4 per cent. of its weight of bromine and had a flash point—1·0° C.
150° to 200° C.	7·8 ,,	0·819	Equivalent to "kerosene" 30 per cent.; its bromine absorption was 7·44 per cent., and its flash point 38° C.
200° to 250° C.	10·4 ,,	0·855	
250° to 300° C.	11·8 ,,	0·890	
Above 300° C. liquid at 17° C.	26·6 ,,	0·914	Equal to 26·6 per cent. of heavy oil.
Under reduced pressure	20·0 per cent., solid, M.P. about 24° C.	0·924	Equivalent to 20·0 per cent. of "solid paraffin" or paraffin scale, melting at 24° C.
Coke and loss	11·4 per cent.		

This oil has a lower percentage of light petroleum than Sample No. 1, whilst the percentages of heavy "oil and solid paraffin" are decidedly high. The amount of coke left after distillation is exceptionally large.

Sample No. 3.—From No. 3 well, near Grande Caille Point. This is an opaque oil similar in appearance to Sample No. 2. The specific gravity is 0·856 and the flash point 19·5° C. (67·1° F.).

Fractional distillation of this oil gave the following results :—

SAMPLE NO. 3.

Temperature at which distilled.	Fractions expressed as volume percentages.	Specific Gravity of fractions.	Remarks.
to 150° C.	7·6 per cent.	0·754	This portion amounted to 8·6 per cent., of which 1 per cent. was water and the remainder "light petroleum." The latter absorbed 2·35 per cent. of its weight of bromine.
150° to 200° C.	14·4 ,,	0·785	Equal to 43·1 per cent. of "kerosene," which had a bromine absorption equal to 2·68 per cent., and flashed at 39° C.
200° to 250° C.	11·9 ,,	0·821	
250° to 300° C.	16·8 ,,	0·850	
Above 300° C.	12·6 ,, liquid at 17° C.	0·874	Equivalent to 12·6 per cent. of heavy oils, having a bromine absorption of 13·14 per cent.
Under reduced pressure	32·0 ,,	0·895	Equal to 32·0 per cent. of "solid paraffin" or paraffin scale, melting at 30° to 40° C., and having a bromine absorption of 16·57 per cent.
Coke and loss	3·7 ,,		

This oil is remarkable for its high percentage of solid hydrocarbons which, as the small amount of bromine absorbed shows, must mainly belong to the paraffin series.

Sample No. 4.—Oil from No. 4 well, on the coast north of Benitie Road. This oil is similar in character to Samples Nos. 2 and 3, but is more viscous than either. Its specific gravity is 0·933. The flash point could not be determined exactly owing to the frothing of the oil, but it is probably above 80° C. (176° F.).

Fractional distillation gave the following results :—

SAMPLE NO. 4.

Temperature at which distilled.	Fractions expressed as volume percentages.	Specific Gravity of fractions.	Remarks.
to 150° C.	1·2 per cent.		Light petroleum with a small quantity of water.
150° to 300° C.	21·0 ,,	0·881	Equal to 21 per cent. of "kerosene," having a bromine absorption of 6·7 per cent., and a flash point —84·0° C.
Above 300° C.	48·2 ,,	0·916	Together forming 73·2 per cent. of "heavy oil," the first portion having a bromine absorption of 16·07 per cent., and the second 52·64 per cent.
Under reduced pressure	25·0 ,,	0·917	
Coke and loss	4·6 ,,		

This sample is remarkable for the small amount of the more volatile constituents it contains and its correspondingly high specific gravity. The percentage of heavy oils is very large. They show a comparatively high bromine absorption.

Sample marked L. S.—No information was supplied regarding the origin of this specimen, but it is presumably from Lizard Spring. It is similar in character to Samples Nos. 2 and 3, has the specific gravity 0·900, and flash point 60° C. (140° F.).

The following table shows the results of its fractional distillation :—

SAMPLE L. S.

Temperature at which distilled.	Fractions expressed as volume percentages.	Specific Gravity of fractions.	Remarks.
below 150° C.	1·0 per cent.		Equal to 1 per cent. of light petroleum.
between 200° and 300° C.	54·0 ,,	0·860	Equivalent to 54 per cent. of "kerosene," having bromine absorption 7·47 per cent., and flash point —48·5° C.
Above 300° C.	24·2 ,,	0·919	Together forming 35·4 per cent. of "heavy oil," having a bromine absorption 19 per cent.
Under reduced pressure	11·2 ,,	0·880	
Coke and loss	9·6 ,,		

The percentage of light petroleum is very low, but that of the kerosene is high, and there is nearly 10 per cent. of coke and loss.

The analysis of Sample B of the first consignment which was also from Lizard Spring gave the following composition :—0·2 per cent. of light petroleum, 70 per cent. of kerosene, 27·4 per cent. of heavy oil, and 2·4 per cent. representing coke and loss. An analysis of a similar sample by Professor Carmody, the Government Analyst of Trinidad, gave a closely concordant result. The present sample, however, differs considerably in composition from that previously examined. It is equally poor in light petroleum, but has less kerosene and more heavy oil and coke, the latter being nearly as high as in No. 2. Either it has been taken from a different well, or there is a variation in the character of the oil produced.

The following table contains in a readily comparable form

the results obtained in the examination of all the samples of Trinidad petroleum so far received at the Imperial Institute.

	Samples received in 1903 per cent.		Samples received in 1904 per cent.				
	A = 1	B = L.S.	1.	2.	3.	4.	L. S.
Light petroleum	11·1	0·2	23·0	12	7·6	1·0	1·0
Kerosene	38·0	70·0	39·5	30	43·1	21·0	54·0
Heavy oils distilled above 300° C. under reduced pressure, Fraction I.	20·0	18·2	26·0	26·6	12·6	48·2	24·2
Heavy oil distilled under reduced pressure, Fraction II.	23·0	9·2	7·0	20·0	32·0	25·0	11·2
Coke and loss	7·9	2·4	4·5	11·4	3·7 water 1%	4·6	9·6
Specific Gravity of crude oil	0·920	0·8686	0·894	0·913	0·856	0·933	0·900
Flash point of crude oil	21·5° C.	71·5° C.	2·0° C.	9·0° C.	19·5° C.	84° C. (approx.)	60° C.

These results show that the percentage of light oil in the products from different wells is related in an interesting manner to the structure of the country, as described by Mr. Cunningham Craig.

Wells Nos. 1 and 2 are situated on the southern anticline that runs from Lagon Bouff across the Pilot River to the east coast just north of Galeota point. Along the line of this anticline the oil-bearing stratum known as "No. 1 streak" reaches or approaches the surface and furnishes the oil to the wells. Here the proportion of light petroleum is decidedly high, amounting to 23 per cent. in the product from No. 1 well, and 12 per cent. in that from No. 2.

No. 3 well, on the other hand, is sunk nearly two miles south of the anticline in somewhat higher beds, the Lower Galeota Sandstone and Upper Galeota Clay (Strata 3 and 4 in Mr. Cunningham Craig's section), and in this case the percentage of light petroleum is only 7·6.

Finally, well No. 4, which is situated in the centre of the syncline between the southern and central anticlines and taps the highest oil-bearing stratum marked 7 in the section and

known as No. 4 streak, contains only 1 per cent. of light petroleum.

There appears, therefore, to be a progressive decrease of the light petroleum from the lowest beds upward which is related to the original position of the beds when deposited, before they were thrown into undulations by earth movements and the upper portion of the anticlines were removed by subaërial agencies bringing the lower rocks to the surface. While the beds were still in their original situation those strata that were lower stratigraphically were also lower in actual position, and the escape of the volatile constituents of the oil contained in them would be more difficult than in the case of oil-bearing strata higher in the series, and covered by a less thickness of subsequently deposited materials; consequently, a larger proportion of the light petroleum would be retained.

The oil from the wells at Lizard Spring seems at first sight to be an exception, being situated close to the central anticline that runs north-east and east to the sea-coast between Moloney Road and Eccles Road, and yet has scarcely any light petroleum. There is, however, no evidence that the lower oil-bearing beds reach the surface at this point, and, according to Mr. Cunningham Craig's section, they do not do so. The oils of these wells may therefore come from higher strata. It must also be remembered that when the oil slowly oozes out from a well it must have been a long time in an open fissure of the rock comparatively near the surface before actually reaching it, and it is not surprising that such oil should have lost the greater part of its volatile constituents. Indeed, Mr. Cunningham Craig expressly states that gas is evolved in this locality. If, however, a well were sunk at Lizard Spring to reach "No. 1 streak," there can be little doubt that oil with a much higher percentage of light petroleum would be obtained there.

THE COMPOSITION AND PROPERTIES OF MINERAL PITCH FROM IJEBU DISTRICT, LAGOS.

THIS sample of pitch was received at the Imperial Institute in February 1904, accompanied by a letter from the Colonial Secretary, Lagos, stating that it was obtained from the Ijebu Territory of the Colony, and requesting that it should be chemically examined with a view to ascertaining whether it possessed any commercial value.

Description of Sample.

The specimen consisted of a rather soft and adhesive pitch which melted fairly completely at 65° C. (149° F.). The material contained, distributed throughout it, portions of dried twigs and leaves, and patches of earthy matter. These last were found by microscopical examination to consist of clear quartz grains embedded in a mixture of decomposed organic matter. The crude pitch had a somewhat unpleasant odour resembling that of guano.

Chemical Examination.

On analysis the composition of the pitch was shown to be :—

	Per cent.
Petrolene (material soluble in acetone)	39·13
Asphaltene (material soluble in chloroform but not in acetone)	19·67
Non-bituminous organic matter and Combined water (by difference)	6·75
Ash	32·83
Moisture	1·62

The composition of the ash was found to be as follows :—

Silica	SiO_2	89·49 per cent.
Alumina	Al_2O_3	7·39 "
Ferric oxide	Fe_2O_3	1·50 "
Lime	CaO	1·08 "
Magnesia	MgO	0·22 "

An attempt was made to separate the earthy material by the process generally used in purifying crude pitch, which consists in maintaining the material in a state of fusion for three days so as to allow the mineral impurities (dirt) to settle. On cooling, a cake of pitch was obtained which was found to be almost equally divided into two layers, the upper containing scarcely any sand, and the lower presenting a dull and gritty appearance.

At the same time the unpleasant odour was completely dissipated. The ash in the upper purified portion amounted to only 6·99 per cent., showing a reduction of approximately 26 per cent., and consisted of a light brown powder containing very little grit.

On a large scale this method of purification would probably be still more effective. Experiments were made as to the suitability of the pitch for the production of asphalt-paving. An intimate mixture of the crude pitch with powdered limestone was warmed to near the melting-point and then pressed till cold. It was found that a combination of one part of the pitch with eight of limestone gave a hard product quite suitable for the purpose mentioned.

A commercial expert to whom the pitch was submitted reported that it was suitable for electrical purposes and for the manufacture of street-paving.

It was suggested, however, that in order to save freight the foreign matter should be separated on the spot, and only the purified material exported. The latter would command a price of from £4 to £4 10*s.* per ton in this country.

These results show that this Lagos pitch, when properly prepared, will possess some commercial value, and it now remains to be ascertained whether the price quoted above for the purified product will be remunerative after the cost of extraction, preparation, freight, and sale have been met. The Imperial Institute will be glad to supply any further information which may be required on this subject.

TINSTONE FROM MADAGASCAR.

THIS mineral was sent to the Imperial Institute by Mr. T. P. Porter, H.M. Consul at Antananarivo, with the request that it might be analysed and its commercial value ascertained.

The mineral was examined in the Scientific and Technical Department, and found to consist of massive tinstone. It was analysed, and gave the following results:—

		Per cent.	
Stannic oxide . .	SnO_2	97·98	equivalent to 77·5 % of metallic tin.
Ferric oxide . . .	Fe_2O_3	0·15	
Calcium oxide . .	CaO	0·20	
Insoluble residue (principally niobic and tantalic oxides)		1·55	

This specimen is therefore a very rich ore of tin, containing as it does 77·5 per cent. of metallic tin, as against the 59 to 72 per cent. found in the best tin ores now worked, but it is scarcely to be expected that when mined on a large scale such a high content of metallic tin will be maintained. The specimen from Madagascar is free from iron and other impurities, and would give a comparatively pure metal on first smelting.

Ore of the same quality as this specimen would probably be worth about £90 per ton at the usual smelting centres at the present time, when ingot tin is worth £135 per ton.

II.—GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

THE ECONOMIC PRODUCTS OF THE MABIRA FOREST, UGANDA PROTECTORATE.

THE following is a report on a journey made by Mr. M. T. Dawe, of the Scientific and Forestry Department of Uganda, and Mr. S. Ormsby, Inspecting Officer of Uganda, through the Mabira Forest of the Protectorate.

From Kampala to Mabira the country is exceedingly undulated, and there is little or no distinction in the flora of the whole route. Here and there in the well-watered valleys and

lowlands near the lake are small forests ranging from 1 to 3 square miles in extent; most of them contain rubber of the following kinds:—Kapa (*Clitandra orientalis*), Mulemu (*Landolphia florida*), Nansali (*L. Dawei*), and the broad-leaved Namukagu (*Funtumia latifolia*) and *Conopharyngia Holstii.* The most conspicuous of the forest trees is the Mpewere (*Piptadenia africana*), its wide-spreading top, covered with chocolate-coloured legumes, together with its huge buttresses, render its distinction easy. A few species of Ficus attain large dimensions, but this timber is usually soft and useless. The "False Nutmeg" (*Pycnanthus Schweinfurthii*) is common, and its timber is also soft and of little or no value. Lusambya trees (*Dolichandrone platycalyx*) occur here and there, also Muvule (*Sterculia sp.*), but the latter is more frequently found on the outskirts of forests or in open land. A species of Artocarpus, a tree 30 to 40 feet high, known to the Baganda as "Musinda," is occasionally to be met with. It is a kind of jackfruit, but not quite so offensive in smell, although by no means appetising. The fruits attain a size of 3 to 3½ feet in circumference, are round with irregular indentations, and covered with brown hairs or bristles. *Spathodea campanulata*, the brilliant scarlet Kifabakasi of the Baganda, is common, and the Ekireketi (*Erythrina tomentosa*) occurs everywhere. Another conspicuous tree is *Kigelia Moosa*, the sausage tree; it is known to the natives as "Moosa," and its thick, soft bark, when pounded, dried, and powdered, is used by the Basesse as a remedy for sores. The tsetse fly is present in all these forests, and sleeping sickness is very prevalent; extensive gardens in their vicinity are almost entirely deserted. The lowlands are particularly fertile in the vicinity of Banda; as an example of its productions, a native brought in a sugar cane over 18 feet long, which had no less than sixty nodes. The moister hollows and swamps are decked with three or four kinds of gaudy Melastomads, such as Osbeckias; also Ipomeas, Labiates, and now and again, flourishing on a stalk 4 or 5 feet long, occurs a rich purple Lissochilus. *L. arenarius* is frequently seen on the plains. The most fertile parts, as a rule, are covered with elephant-grass (*Phragmites communis*), and this usually monopolises the land, allowing little to grow amongst it with the

exception of a few creepers. The hill-sides are for the most part covered with an Andropogon grass, which contains, like the Ceylon species, a fragrant essential oil; this by culture may be developed, and be useful in local soap manufacture. Amongst low or burnt grass occurs the Uganda daisy (*Gorbera sp.*) in profusion, and side by side, on stony land, is to be seen a Hypericum, the appearance of which, together with the daisy, tends to remind one of the flora of the north temperate zone. Twining over old, deserted, and overgrown gardens, one meets with Semuye (*Physostigma venenosum*), or Calabar beans as they are termed in commerce. An indigo plant is found occasionally throughout the route. Bugogwa, or Sanseviera, the Uganda fibre plant, occurs in forest and bushland, but is usually of the smaller kind, and is not so common as in Buddu and Buyaga.

The Mabira Forest differs considerably in character from the smaller forests near the shores of Lake Victoria Nyanza. As one enters it near the little garden of Bukalamu, one is immediately struck with the length and straightness of the trees, and of the entire absence of the majority of trees which characterise the forest of Western Uganda. The conspicuous Mpewere (*Piptadenia africana*) is entirely absent (a tree is known to the natives of the forest as Mpewere, but it is not the Piptadenia, common in Buddu and Busiro), as is also the "False Nutmeg" and the incense tree (*Canarium Schweinfurthii*). Further, the forests of the Lake shore regions of Western Uganda are remarkable for trees with huge protruding buttresses, especially those with large outspreading tops, which is undoubtedly a provision of Nature to secure the safety of the tree against the high winds that so frequently precede storms. On the islands, where violent storms are particularly frequent, tall, straight-boled trees, such as Omukusa, send out huge roots as supports from the trunk, even as high as ten feet from the ground. The Mabira is less exposed, and Nature has not adopted such protective measures to such an extent as above described, which is a great advantage from a timber point of view. There are also a larger variety of useful timber trees than occur in the majority of Uganda forests, and for the most part are of more durable kinds, which may be attributed to the less humid conditions that on the

whole prevail. The trees are closely distributed,—as many as fifty, a foot and over in diameter at 4 feet from the ground, occur to the acre in some parts. Towards the north-west of the forest, however, and in many other parts, the trees are not so thick, and in the more central parts the forest is frequently intercepted by grassy plains and small hills, which are studded with useless small trees. It would be approximately correct, therefore, to estimate that there are on an average twenty-five good timber trees to the acre of a girth of 3 feet upwards. It is most difficult to arrive at anything like an accurate estimate of the extent of the forest until it is properly surveyed; we think, however, that former estimates have been exaggerated, and that the actual forest does not exceed 140 square miles. Trees of large dimensions occur in the central and north-west parts of the forest; a Muvule measured just over 18 feet in circumference; unfortunately such large trees are frequently diseased or attacked by borers, and the lower central portions are hollow. It is about 8 miles from the nearest and most accessible part of the forest to Jinja ferry. An excellent line of country, affording easy gradients and curves, connects it with the cart road at 3 miles from the ferry. To facilitate the transport of timber, a road about 5 miles long would therefore have to be made to connect the forest with the Jinja road.

Timber specimens of the following kinds have been procured in triplicate—one set for the Timber Museum, Royal Botanical Gardens, Kew; another for the Manager, Uganda Railway; and a third for our Scientific and Forestry Department:—

No. 1. *Sesambya.*—A tall, straight tree, height 60–70 feet, girth 6–9 feet, has unbranched bole to a height of 30–40 feet; timber white or light brown, very even and close-grained, hard and durable; trees plentiful.

No. 2. *Lusambya* (*Dolichandrone platycalyx*).—Tree of dimensions similar to above; timber white or whitish yellow, very tough and durable; used largely for house-building; trees very plentiful.

No. 3. *Mukole* (*Sterculiaceæ*).—Much-branched tree, clear bole 15–20 feet, girth 6–8 feet; timber hard, heart wood walnut colour, good grain, polishes well.

No. 4. *Nongo.*—Tall straight tree, 70–80 feet high, clear trunk 40–50 feet, girth 8–14 feet; wood even-grained, light yellow, said to be subject to insect attacks.

No. 5. *Mpewere* (of Chagwe; this is not the Mpewere of Western Uganda, which is *Piptadenia africana*).—Tall tree, similar dimensions to Nongo wood; very light and white in colour.

No. 6. *Mugavu or Mutampindi* (*Leguminoseæ*). — Wide-spreading tree, with short trunk and large branches; wood mahogany colour, extremely hard, heavy, and durable.

No. 7. *Musogasoga.*—Tree 50 feet high, clear trunk 20–25 feet; wood white, very light.

No. 8. *Mukebu.*—Tall, straight tree, 50–60 feet high, trunk 30–35 feet, girth 6–10 feet; wood brown and mottled, said to be fairly durable.

No. 9. *Muvule* (*Sterculia sp.*).—Tall, straight tree, 70–80 feet, bole 40–50 feet, girth 8–18 feet; wood yellowish brown, extremely hard and durable, and of the most useful of Uganda.

No. 10. *Kasisa.*—Tall tree, 60–70 feet, bole 20–35 feet, girth 8–12 feet; wood whitish, fairly heavy and liable to split.

No. 11. *Mwojolo.*—Straight tree, about 60 feet high, bole 20–35 feet, girth 6–10 feet; wood very light in colour, hard, even grained, and very useful.

No. 12. *Mpimbya.*—Erect tree, 70–80 feet, bole 30–40 feet, girth 6–9 feet; wood fairly hard, light in colour, with peculiar dark markings.

No. 13. *Baluegira.*—Tall tree, 70–80 feet, trunk 40–50 feet, girth 6–12 feet; wood light in colour, heart wood brown, fairly hard; when freshly cut has very offensive odour.

No. 14. *Mubajangabo* (*Zanthoxylon*).—Tall, straight tree, bark studded with brittle, corky protuberances, which have a thorn at the end; branches all covered with thorns; height 50–70 feet, trunk 30–40 feet, girth 5–7 feet; wood very even grained, yellow, hard, and durable; useful for panels, etc.

No. 15. *Mubajangalabi.*—Tree 50–60 feet, with bole 20–30 feet, girth 6–10 feet; wood soft, light, white in colour; bark contains latex.

No. 16. *Joge.*—Erect tree, 70–90 feet, bole 30–45 feet, girth 6–10 feet; wood dark, hard, heavy and durable.

Botanical specimens of unidentified species have been procured, and will in due course be forwarded to Kew for identification; it should be mentioned that they are very incomplete, as this is the dormant season. Few trees, indeed, have either flowers or fruit, so their determination will be very difficult; it will, however, be arranged later to procure and forward more complete specimens.

A tour was made by a side route to Kyabyzala, the extreme north-west end of the forest, where the two rivers, Sezibwa and Musamia, unite. The return journey to Bakalamu (first camp) was made through the centre of the forest. Near the village of Dangala large gardens are deserted, and the odour of decaying bananas fills the air. Many of the natives have died of sleeping sickness, and it is interesting to note with this that few tsetse flies indeed are found in the forest, especially in the drier parts. A further number of the natives are said to have been driven from the forest by the little poisonous mbwa fly (*Simulium damnosum*), and those that remain are for the most part diseased, and afford an ill representation of the Baganda as a race. The forest is cheerless and gloomy, and there are practically no birds in the central parts; scarcely a sound is heard save the shouts of porters, the falling of dead branches, or at night the howls of leopards, hyænas, and jackals. Monkeys seem to shun the place —only a few were seen, and those in a side branch of the forest near a village. Elephants have deserted the place long ago. There are buffalo, ntalagana, and wild pig in abundance.

In travelling through the forest insects are by far the most formidable enemy to encounter; the mbwa fly ranks first, and although very small, its bite is very poisonous, which causes great irritation and raises large swellings that usually end in sores. The mosquito ranks next, and is in most parts very bad. Then comes a little brown ant, which rambles on long grass and undergrowth, it bites one severely and causes swellings; unfortunately it is impossible to avoid these as there are no roads, and in many places one has to cut a way through. Then armies of the nsanafu ant are particularly abundant throughout the forest. The natives hang a flat, dried fungus above the hearth, which they believe prevents them passing through the hut.

The country at Kyabyzala is very disappointing, the area

near the junction of the two rivers is covered with flat-topped Acacia trees and long, coarse grass, and nothing can be seen of the rivers but pampas grass as far as the eye can reach. There are very few rubber vines in the forest, it is only in the wings or outskirts of the forest that there are any. A Landolphia with obovate leaves was found. It is probably a new species, but unfortunately cannot be determined at present, as it bore no flowers or fruit. A far more important discovery, however, is that of one of the West African tree rubbers, evidently *Funtumia elastica*, Staph., synonymous with, and probably better known as, *Kickxia elastica*, Pruess. It is very abundant, especially in the central parts and near Kabagano. The natives do not distinguish them in name from *Funtumia latifolia* and *Conophoryngia Holsteii*, but call them both Namukagu. It is, however, very distinct, the leaves are much narrower, and the bifid fruits or follicles resemble those of a Strophanthus, while those of *Conopharyngia Holstii* are almost globular, with a central de pression like a plum. It is more difficult to distinguish between *F. elastica* and *F. latifolia;* the former may be identified, however, by small pits or depressions which occur at the functions of the veins, with the midrib on the under sides of the leaves. The tree is from 3 feet to 5 feet in girth, and grows 40 to 90 feet high, and usually has a clear bole to a height of 30 feet.

As before mentioned, most of the trees are in a resting condition, and there is little movement on the part of the latex. The rains having just commenced, and falling every day, has rendered the collection of latex even in sufficient quantity for experimental purposes impossible. Another visit should be made here shortly, when the trees are in vigorous growth, to get samples of the rubber, for should it yield a good rubber as in West Africa, and I have reason to believe it does, it could be easily grown in plantations systematically, in a manner that we can never hope to with the Landolphia or Clitandra vines.

Several plants of botanical interest were found. One especially (*Thormingia Sanguinea*) is interesting. It occurs in forest-land, and has for the most part a subterranean existence. It is parasitic on the roots of trees, and now and again makes its presence known by sending up most brilliant scarlet rosette-like flowers. Ferns are plentiful in some parts, but there is

not such a variety as in most of the forests near the Lake. The undergrowth is largely composed of Scitaminious plants such as *Amomum Granum-Paradisi* and Marantas; also Peperomias, Phyllanthus, Dracæna, and Palisota. The aromatic fruits of the Amomum are greatly relished by the Baganda, and are known to them as Butungulu. Their baskets are made of the rattan-like stem of Maranta. A Zizyphus is very common, and its fruits, although rather acid, are eaten by the natives. The rattan palm occurs in some parts, but is not particularly common.

Attached is a comparative meteorological statement showing the variations of temperature, etc., between the Mabira Forest and Entebbe.

Appendix No. 1.

A COMPARATIVE Statement of Dew Point, October 1904.

Date.	Bukalamu.—Mabira Forest.			Entebbe.		
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.
October 14 . .	—	—	67·2	—	—	65·0
,, 15 . .	65·2	63·8	62·4	62·4	60·6	63·7
,, 16 . .	61·4	59·8	62·4	62·2	70·2	61·4
,, 17 . .	61·2	—	61·6	60·3	—	64·4
,, 18 . .	61·4	57·2	61·4	60·3	69·8	61·4
,, 19 . .	63·4	65·9	62·6	62·4	72·9	66·7
,, 20 . .	63·2	63·2	62·4	63·2	71·6	64·2
,, 21 . .	61·4	64·3	63·2	61·2	60·0	65·2
,, 22 . .	60·3	59·8	56·7	59·3	72·9	64·4
,, 23 . .	62·2	62·3	61·1	62·2	63·0	65·2
,, 24 . .	59·3	65·7	62·6	60·1	63·6	64·2
Means . . .	61·9	62·4	62·1	61·4	67·2	64·2

Appendix No. 2.

A COMPARATIVE Statement of Relative Degrees of Humidity, October 1904.

Date.	Bukalamu.—Mabira Forest.			Entebbe.		
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.
October 14 . .	—	—	94	—	—	79
,, 15 . .	94	59	88	88	59	83
,, 16 . .	88	50	88	94	79	88
,, 17 . .	94	—	83	88	—	88
,, 18 . .	88	52	88	88	84	88
,, 19 . .	88	60	83	88	84	84
,, 20 . .	94	56	88	94	89	94
,, 21 . .	88	74	94	94	56	94
,, 22 . .	88	50	77	88	84	88
,, 23 . .	94	63	73	94	66	94
,, 24 . .	88	71	83	94	70	94
Means . . .	90	59	85	91	75	89

Appendix No. 3.

A COMPARATIVE Statement of Maximum and Minimum Temperatures, October 1904.

Date.	Bukalamu.—Mabira Forest.		Entebbe.	
	Maximum Temperature.	Minimum Temperature.	Maximum Temperature.	Minimum Temperature.
October 14	—	59·0	—	64·1
,, 15	79·0	60·0	80·8	65·0
,, 16	80·0	61·0	79·8	65·4
,, 17	79·0	58·0	79·0	61·3
,, 18	78·0	58·0	80·0	62·0
,, 19	81·0	58·0	79·0	60·0
,, 20	80·0	58·0	77·5	63·5
,, 21	81·0	59·0	77·5	62·1
,, 22	81·0	60·0	79·0	60·5
,, 23	81·0	63·0	76·1	63·9
,, 24	81·0	61·0	76·0	61·1
Means	80·0	59·5	78·5	62·6

COTTON GROWING IN NORTHERN NIGERIA.

A SERIES of articles has appeared in previous numbers of the *Bulletin of the Imperial Institute*, giving an account of the present state and future prospects of cotton growing in various parts of the world, both British and foreign. A memorandum on this subject by the High Commissioner of Northern Nigeria, compiled from reports prepared by Resident Officers in the Protectorate, has been received recently at the Imperial Institute, from which the following information is taken.

Northern Nigeria is one of the most promising of the new fields that are being opened up to join in supplying Lancashire with cotton. It stretches for 700 miles from the French Territory of Dahomey on the west, to Lake Chad and the German Came-

roons on the east, and for over 400 miles from the French Sudan on the north, to the boundaries of Lagos and Southern Nigeria on the south. The rivers Niger and Benue traverse it near its southern boundary, and numerous tributaries flow from the north into these; so that the country is well supplied with waterways, which afford easy means of transporting the cotton from the interior to the coast for shipment to England. The light railway from Zungeru to Zaria, which is contemplated, will also open up new districts suitable for cotton cultivation.

In this part of Africa the districts near the coast are covered with heavy forests; palm oil, rubber, and other industries are carried on with which cotton cannot compete in point of attractiveness to the native, and the rainfall is too heavy to be favourable to cotton growing. Further inland the country becomes more open, and in Northern Nigeria, the southern boundary of which is 200 miles from the sea, the rainfall is moderate though sufficient; and there is a much better prospect of the development of an export trade in cotton, notwithstanding the competition of other industries.

Large areas of land are suitable for cotton growing, which has been practised by the natives for many hundreds of years. The native cotton is reported by an expert of the British Cotton Growing Association, who visited the country in 1904, to be fine and white, of good strength, not quite as smooth as American, and to be about one inch in staple and to be suitable for use in Lancashire in unlimited quantities. He formed a most favourable opinion of the possibilities of cotton growing in this Protectorate, and stated that the soil was well adapted for growing American seed. Imported seed has been taken eagerly by the natives, and has given yields considerably above those given by the indigenous variety. It is believed that cotton cultivation will bring with it many improvements in the agriculture of the country, such as the use of improved implements, ploughs, carts, and the use of draught animals. Oxen, horses, mules, and asses thrive in Northern Nigeria, although they fail on the coast, so that their use in agriculture is possible.

As regards the steps to be taken to develop the industry, there are two methods of attaining an export trade in cotton: the first

is to encourage the native production as much as possible; the second is, by the creation of large plantations under European supervision. It is considered that the former of these is the one to which the efforts of the Government should be directed, and such efforts need be no hindrance to the development of the second plan.

Reports coming from the Residents in charge of the various districts into which Northern Nigeria is divided, show how widely cotton cultivation is extended throughout this Protectorate. The report from the province of Nupe is very full, and from it the following details are gathered.

This province is especially well suited to the cotton industry. It lies on the north bank of the Niger, and is traversed by many tributary streams, so that the most distant centres of cotton growing are nowhere more than two days' journey from a river. Cotton is already grown throughout the province, the best districts being situated near the Gurara and Bako rivers and to the west of the Kaduna river. Up to October 1903, however, the crop was only grown to supply local needs. The plan adopted in the neighbourhood of the market town of Bida will serve to give an idea of the native methods of growing and employing cotton.

The crop is raised on small patches of only one or two-tenths of an acre in area, and these only form some half per cent. of the cultivated land of the farm. The cotton is grown on land which has been used for some time for millet. A piece of new land is first cleared of the long grass and small trees that occupy it; the roots are then removed, and mounds of earth about a foot high and four feet apart are scraped up by means of rude hoes. These are made from local iron, and might with advantage be replaced by light English hoes such as are used in India. Crop after crop of "dawa" (that is, guinea corn or great millet, *Sorghum vulgare*), and "gero" (African millet, *Pennisetum typhoidium*), which are sown together on each mound, are taken off the land, until only very poor yields are obtained. The land is then allowed to lie fallow for a few years; after which a good patch is selected and the cotton is planted during July and August, when the soil is well saturated by

rain, the seed being dibbled in in the centre of the old mounds.

The quantity of seed used is much less than is customary in Egypt, where from eight to fifteen seeds are placed in each hole, and about 1⅛ bushel of seed is used per acre. Here the plants are much further apart, namely, four feet each way, and only three or four seeds are placed in each hole; so that two or three pounds of seed is all that is required per acre, and the need for thinning the young plants is avoided. About six or seven thousand plants mature per acre. The distance between the plants is, as a rule, too great, and involves a loss both in labour and yield. The rains are usually good, consequently irrigation is not needed.

The first picking, which is the best of the three, is made in December, and may amount to two or three hundred pounds per acre; the second picking takes place some forty days later and yields about half the quantity, and the third and final picking is completed in February; it is of poor quality and amounts to only about one-third of the first. The yield per acre has not yet been ascertained with any precision; but it is thought not to exceed 500 lb. of seed cotton (that is, the seed with the lint attached) per acre on the average, though it has been estimated at a much higher figure than this on good soil in a good season.

The cost of the labour devoted to cotton is very small; but as the farmer's family help in the work it cannot be ascertained with exactitude, and the following estimates in terms of one day's work of one man must be taken as being only rough approximations. The total labour given to a crop may be taken as being 62 days' work per acre, distributed into 24 days for the preliminary clearing, 2 days for the sowing, 6 days for each of four weedings, and 4 days for each of the three pickings. On a native farm the cost per day for a labourer may be estimated at 385 cowries, or about 1½*d.* (250 cowries are about equivalent to 1*d.*); so that the labour involved in growing a cotton crop amounts to only 7*s.* 9*d.* per acre. It should be noted, however, that on a plantation conducted by white men the full rate of 9*d.* a day would have to be paid.

The retail price of seed cotton at Bida is approximately

1*d.* per lb.; and the Niger Company are buying all the cotton they can get at Egga and other riverside stations at this price. The grower, however, does not receive more than half of this, unless he brings his crop to market and sells it there himself. He usually disposes of it to women traders, who come to his farm and carry it away. Thus for a crop of 500 lb. per acre he would receive £1 0*s.* 10*d.*, which would give him 4*d.* a day for the sixty-two days' work. This estimate shows that under favourable conditions the cultivation of cotton is fairly profitable.

It is judged that one farmer, with the help of his family, could cultivate five acres of cotton without interfering with the raising of his usual food crops. The important question arises whether he can be induced to do this. One incentive that might be tried is the enactment that part of his tribute should be paid in cotton; and it is hoped that the security for property and the freedom from exactions now resulting from the administration of justice will afford an inducement which did not exist before under the Fulani rule, and will before long be appreciated and produce its effect.

Some remarks on the native trade in cotton, when uninfluenced by the recent opportunities for exporting it, will aid in forecasting the future. The women traders referred to above carry the cotton to the market and sell it to other women, who gin it and spin it by the most laborious processes. A woman buying 1·6 lb. of seed cotton for 400 cowries (1·6*d.*) gins it in one day, and sells the resulting pound of cotton seed for 250 cowries (1*d.*), to be used as food. In three days more she can spin the lint into yarn for the local weavers, and sell it for 1,000 cowries (4*d.*); she thus clears 850 cowries (3·4*d.*) for her four days' labour; that is, 212·5 cowries or 0·85*d.* per day. The Niger Company is now offering 4*d.* per lb. for ginned cotton. If the woman after ginning the 1·6 lb. of seed cotton sells the resulting ½ lb. of lint instead of spinning it, she will receive 2*d.* for the lint and 1*d.* for the seed, and clear 1·4*d.* for her day's work; it is therefore greatly to her advantage to sell the lint to the Company.

This advantage, however, will not be shared with the farmer; but it is thought that by introducing ginning machines some of the benefit will reach him, and so stimulate a greater inclination

to grow cotton. The present cost of ginning 100 lb. of seed cotton by hand may be taken as 8*s.* 4*d.*; in Togoland a machine gin was used actuated by an improvised gear employing man-power as the driving agent, and the cost was 1*s.* for ginning the same quantity. In Egypt a 40-inch knife gin, capable of ginning 315 lb. of seed cotton per hour, costs £22; it requires $3\frac{1}{2}$ horse-power to drive it, and the price charged to the growers is only $5\frac{3}{4}$*d.* per 100 lb. That gins can be worked by the natives is shown by the considerable success that attended the presentation of one by the Niger Company to the Emir of Bida sixteen years ago. The gain by using machinery is thus very great, and in time the farmer might be induced to bring his cotton to gins established at various centres, and reap some of the benefit of the saving in labour. He might possibly get 10*s.* for the lint and 4*s.* for the seed for every 100 lb. of seed cotton he produced, thus receiving £3 10*s.* per acre, instead of the £1 0*s.* 10*d.* he realises at present.

As a first step in this direction it is suggested that gins might be presented to the chiefs of various towns, who should be allowed to charge a fair rate for ginning, but make no other profit. A fair rate to allow for carriage to the market would be 1*s.* 6*d.* per day's march for 100 lb.

At present the farming of the province is almost entirely devoted to growing food crops, and locally they are more profitable than cotton, but the demand for them is limited to the immediate neighbourhood of the farms; they will not bear the cost of transport to a distance, whilst cotton can be easily transported with a view to profit.

The immediate steps to be taken should evidently be in the direction of inducing the native farmers to grow more cotton; but the possibilities of growing this staple on large plantations should not be overlooked. On the one hand the European would have to pay much more for his labour than the native farmer, namely, the full rate of 9*d.* a day; but on the other hand he could effect economies by the use of horse-drawn ploughs and by employing wheeled vehicles for transport. There is abundant labour available near the villages, and an enormous extent of good cotton soil practically untouched;

but such projects should only be taken up by firms with large resources and after careful investigation.

RAMIE, RHEA, OR CHINA GRASS.

As requests for information respecting the cultivation and possibilities of ramie fibre are constantly received at the Imperial Institute, it has been thought desirable to publish a statement on the subject.

Ramie fibre is derived from a plant of the Natural Order *Urticaceæ*, or nettle family, which grows to the height of 4 to 8 feet, and in appearance, habit, and growth somewhat resembles the common nettle of this country, but is devoid of stinging hairs. There are two forms of this plant. One of these, the China grass plant, which has been cultivated by the Chinese from very early times under the name of "ch'ü ma," is known botanically as *Bœhmeria nivea.* The other form, which is called in Assam, rhea—and in the Malay Islands, ramie—is regarded as a variety of the true China grass plant, and is known as *B. nivea* var. *tenacissima.*

The true China grass plant is cultivated chiefly in China and Formosa, whilst *B. nivea* var. *tenacissima* is adapted to growth in tropical countries such as the Malay Islands and Mexico. The Indian plant has been stated by many writers to be the form *B. nivea* var. *tenacissima*, but Sir George Watt, who has made a special study of this point, affirms that it is the same variety as the Chinese plant.

The fibre afforded by these plants is undoubtedly one of the strongest and finest known. It is extremely durable, and is said to be less affected by moisture than any other fibre, but is somewhat lacking in elasticity. Ramie fibre has a brilliant silky lustre, can be dyed readily, and is exceptionally long, the ultimate fibres varying from 3 to 16 inches in length.

Cultivation.

The ramie plant is easy to cultivate and thrives in almost any soil, but is especially adapted to a naturally rich, moist soil of a light loamy character. In China it is usually grown on a red clay containing sand. In the United States it has been cultivated experimentally on a great variety of soils, and it has been found that the plant grows best on light, sandy, alluvial soils, although it will flourish on any good soil which is capable of retaining its moisture throughout the growing season. In order that the growth of the stems may be rapid and continuous, a hot, moist, and equable climate is required.

The ramie plant withdraws from the soil a large quantity of valuable constituents. As only a small proportion of these materials is contained in the fibre it must be advantageous, on general principles, to return as much as possible of the refuse of the crop to the land. Experience has shown that without liberal general manuring the yield of fibre diminishes, and that the application of organic manures such as liquid manure, farm-yard manure, guano, or oil-cake is very beneficial. These fertilisers can sometimes be supplemented with artificial manures.

The propagation of the ramie plant is effected by means of seed, cuttings or layers, or by division of the roots. When the plant is grown from seed, it is usual to sow it in the hot-bed and to transplant the seedlings after five or six weeks' growth. The method of growing the plants from cuttings is practised in some parts of India. The stems are cut in the spring, only the portions which have turned brown being employed for the purpose. The cuttings usually include three buds, a margin of a quarter of an inch being allowed at each end beyond the top and bottom buds respectively. When the plant is propagated from root cuttings, the young lateral shoots with their roots are cut off and planted about a foot apart in furrows four inches deep.

The amount of moisture supplied to the plants during their growth must be carefully regulated. If an excess of moisture

is present the plant grows rapidly, but produces a fibre of poor quality. If, on the contrary, the plant is unable to obtain sufficient water, its growth is retarded and it becomes stunted. When these two opposite conditions both occur during one season, the plant yields a fibre of mixed quality and irregular strength, which is liable to suffer considerable loss in its extraction and preparation for spinning.

Preparation of the Fibre.

The fibre known in commerce as "China grass" is prepared in China entirely by hand. The stems are first stripped, and the epidermis or cuticle is removed by scraping and washing, different methods being employed in different parts of the country. The process is tedious and expensive, as the preparation of a few pounds of the ribbons constitutes a day's work. In the resulting product the fibres are firmly embedded in a gummy substance of a pectose-like nature, which must be removed before the fibre can be spun into yarn. The operation of degumming is not carried out in China, but is effected subsequently in Europe by chemical means.

The preparation of China grass by hand stripping can only be made remunerative in countries where labour is exceedingly cheap and plentiful, and consequently numerous attempts have been made to invent suitable decorticating machinery. In 1869, the Government of India offered a reward of £5,000 for the best machine for decorticating the green stems, and a trial was held in 1872. No machine, however, completely fulfilled the requirements, and the full prize was not awarded. The reward was again offered, and a second official trial took place in 1879, but with no greater success. The effect of these competitions was to stimulate invention, and, in consequence, numerous decorticating machines have been produced, but many of them have given very disappointing results. A gradual improvement, however, has taken place, and, at the present time, the difficulty of decorticating ramie stems by machinery may be regarded as solved.

Ramie machines are of two kinds, namely, those that merely strip the bark in ribbons from the stems, and those that not only do this but further make some attempt to remove the outer or epidermal layer from the ribbons. Machines of the first kind usually consist of rollers which crush the stems, and beaters which separate the woody portion from the bark. Those of the second class possess also some mechanism by which a scraping effect is produced on the strips of bark, and the material prepared in this way resembles hand-cleaned China grass.

The fibre having been separated from the stems in the form of strips or ribbons, the next stage in its preparation is the process of degumming. The object of this operation is to dissolve and wash out the gummy substances without attacking the cellulose; the epidermis becomes detached in the process and may be removed from the fibre by washing. Many methods have been invented for degumming ramie fibre, and satisfactory processes have now been obtained, but, as a rule, the details are not published or patented, but are jealously guarded by the manufacturers. The following description will serve as an indication of the kind of treatment to which the material is subjected. The ribbons are boiled in dilute soda, are then exposed to the action of solution of bleaching powder, and are afterwards immersed in a bath of dilute acid, the two latter processes being repeated until the whole of the gum has been extracted. The result of this treatment is the production of a white, lustrous fibre known as the "filasse."

On account of the liability of injury to the fibre by the use of too severe treatment in degumming, ramie spinners usually prefer to buy the fibre in the form of ribbons, and degum it by their own process.

A method has been devised recently for the preparation of ramie fibre, by which it is claimed that the finest filasse can be obtained without the use of chemicals. According to this system the stems are stripped by a simple decorticator of the first type described above, no attempt being made to remove the epidermis, and the ribbons are treated by a special de-

gumming process by means of which a beautiful, clean filasse is produced.

Ramie fibre offers certain difficulties in the processes of manufacture, one of which is its tendency to cling to the rollers in the operations of drawing and spinning. At one time, manufacturers attempted to spin the fibre with machinery suitable for cotton, wool, or flax, but these efforts ended in failure. It was realised eventually that success in ramie spinning could only be attained by the use of machinery specially adapted to the manipulation of the fibre. Such machines have now been invented, and their employment has rendered it possible to utilise ramie fibre with commercial success.

Ramie fibre is exceedingly strong and fine, and could be used for the manufacture of many materials for which cotton, wool, or flax is now employed. It has been used successfully in combination with wool, for the production of certain classes of fabrics. The fibre is woven into goods of various descriptions such as lace, curtains, handkerchiefs, tablecloths, counterpanes, plush, carpets, and even clothing materials. It is also employed for the manufacture of mantles for incandescent gas lighting, and is said to furnish an excellent paper pulp suitable for making bank-notes.

From the foregoing particulars it is evident that a considerable field exists for the development of ramie cultivation. The real problem is cheap production. The planter must proceed cautiously, and it would be well for him first to prove the suitability of the soil and climate by growing an experimental area of a few acres in extent. He should then ascertain that the fibre grown is of the right quality to command a market, by preparing and sending to this country a small consignment of the product for examination and report. Such samples should consist of about 1 cwt. of the ribbons, and should be carefully dried and baled before export.

FUNGOID DISEASES OF THE COTTON PLANT.

ONE of the principal difficulties experienced in the cultivation of cotton, and especially where a variety of cotton is introduced into a new country, is its liability to attack by insect pests and fungoid diseases. A considerable amount of attention has been devoted to the former, but it is only comparatively recently that similar attention has been directed to the no less important subject of fungoid diseases.

Reference has already been made in this Bulletin (Vol. ii., No. 4, page 253) to the occurrence of the so-called "American wilt disease" in Togoland. The same fungus has been discovered recently in German East Africa. Previous to 1903 the cotton plantations in the latter colony had not exhibited symptoms of the disease, but in that year roots of some of the cotton plants in the newly-formed plantations were found to be affected, and specimens of these were sent to Dr. Zimmermann for investigation. By microscopic examination of the diseased material he found a fungus to which the disease was traced. An account of the work is given in *Berichte über Land- und Forstwirtschaft in Deutsch-Ostafrika, Band II., Heft I.*, and the following is a brief summary of the results:—

I. ROOT DISEASE CAUSED BY *NEOCOSMOSPORA VASINFECTA*, SM.

Early in March 1903 Dr. Zimmermann received from a plantation at Mombo in German East Africa some withered cotton plants, of which the roots were diseased, while the parts above ground were still healthy. It was obviously a case of root disease. Microscopic investigation of the roots indicated that they had been penetrated by a fungus, which was visible, under the microscope, upon the diseased parts of the roots. Dr. Zimmermann subsequently investigated the disease at the plantations in Mombo, and found on the roots fungi which corresponded exactly and were identical with the American fungus

described by Smith under the name *Neocosmospora vasinfecta*. In the United States the "wilt disease" has been found to occur not only upon cottons (*Gossypium herbaceum* and *Gossypium barbadense*), but also upon the water-melon (*Citrullus vulgaris*) and the cow-pea (*Vigna sinensis*). Fungi observed on these various plants were indistinguishable. Further proof that the fungus is actually the cause of the disease was afforded by the fact that it was found possible to artificially induce the disease in the water-melon by infecting the surrounding soil with the spores of the fungus. Moreover, the pathological symptoms observed in cotton and the cow-pea were identical, and the symptoms re-appeared on the same land year after year. It seems that all these plants were attacked by the same kind of fungus, which apparently penetrates the roots while these are young. It remains for future investigation to ascertain under what special external conditions spontaneous infection and the spread of the disease take place.

In Mombo the death of cotton plants gradually spread from two places in all directions with all the appearances of an infectious disease. To prevent it from spreading still farther, all sickly plants, and sound plants on the margin of the diseased tract, were uprooted and burned, the area infected being carefully marked and not planted again with cotton.

The disease may re-appear in land which has lain fallow for several years, and is difficult to eradicate. A trench, which should be somewhat deeper than the deepest roots of the cotton plant in order to prevent the disease from passing through the soil from infected to healthy roots, should be dug around the infected area so as to completely isolate it. Diseased roots should not be thrown upon the manure heap. The selection of resistant races of cotton seems to be the best method of dealing with this disease. The disease is recognisable by the dwarfing of the plants, and the yellow colour assumed by the leaves.

II. DIPLODIA (*GOSSYPII*, SP. NOV.).

Dr. Zimmermann found on the same roots a new fungus, which has been named *Diplodia gossypii*: spores of this were yielded in great abundance from the roots when kept in moist air. It is considered that this fungus is a comparatively harmless secondary parasite, occurring in association with the "wilt disease" proper.

III *PHYLLOSTICTA GOSSYPINA*, ELL. & M.

A third fungus was found by Dr. Zimmermann on the roots of *Gossypium herbaceum* (American cotton). It seems to be identical with a fungus described by Saccardo, *Phyllosticta gossypina*.

IV. *ALTERNARIA MACROSPORA*, SP. NOV.

This is another fungus which attacks Egyptian and American cotton, and has been observed on the dead leaves as well as on parts of the fruit capsules which have turned black. It is uncertain as yet whether this fungus is the cause of the death of the parts affected, or whether it is only a secondary parasite of little importance.

THE CULTIVATION OF BANANAS AND PINEAPPLES.

THE Canary Islands and Madeira, until a few years ago, were able adequately to supply both the British and Continental fruit markets with bananas and pineapples, but the large quantities of these fruits now required cannot be grown by these small islands. As a result of the improved steamship communications, an extension of the producing area has been effected in West Africa

and the West Indies, the nearest countries accessible by sea which are suitable for the cultivation of these fruits.

In point of accessibility, and in the possession of suitable soil and climate, as well as cheap and abundant labour, the littoral of French Guinea immediately north of Sierra Leone is considered by the French colonial authorities to be one of the most promising regions in West Africa for the development of a fruit trade, and it is believed that French Guinea will be able to compete with British importations from the West Indies, and even to replace them on the London market. For this reason it has been considered advisable to give here an account of what is being done in this direction in the French Colony.

In this connection the volume entitled *Bananes et Ananas*, written by M. Yves Henry, and recently published by Challamel and Co., Paris, is of importance.

French Guinea possesses a hundred miles of railway, terminating at a harbour capable of accommodating ships of 4,000 tons. The cost of land is insignificant. The coast regions are well watered with innumerable creeks. Rice is the chief crop, but the oil palm and kola are also grown in abundance, and the country produces cereals, etc., enough to support a fairly numerous population. There is a wet and a dry season, each of six months' duration; the wet season lasting from May to October, and the dry season from November to April. Farther inland, fertile valleys, the soil being laterite, penetrate the high plateaux of Fouta Djallon, which separate the head waters of the Gambia from those of the Niger.

BANANAS.

The fruit plantations were stocked with *Musa sapientum*, but the planters are not now in favour of that species, and the smaller species, *Musa sinensis* (*M. Cavendishii*), is being planted on all the estates. Several varieties of *M. sinensis* are recognised, one of them being the "Canary banana." Another, the so-called "Camayenne banana," a local variety which takes its name from a district on the coast, produces large fruits with broad spaces between the individual fruits as well as between the hands, so

that the bunch as a whole is much less compact than that of the "Canary banana." The stalk which bears the fruit is somewhat long. Owing to these characters, a bunch of Camayenne bananas takes up a good deal of room when packed, and the fruits have a tendency to turn black at the base and drop off in transit. Hence the Paris fruit market exhibits a decided preference for the "Canary banana." Another variety of *M. sinensis* occurs in French Guinea, but at present is very little known, and does not seem to be of much value. It is cultivated by the natives near rivers in the valleys of the territory adjoining Sierra Leone.

Propagation.

The rapid expansion of banana growing in French Guinea has caused a demand for young plants of the best varieties, particularly the "Canary banana," for purposes of propagation. An experimental station supplies suckers in as large quantities as possible to planters. In future a minimum of 50,000 suckers per annum will be available, and these may be purchased by planters at a uniform price of fourpence per sucker. A single banana plant sometimes throws out at its base as many as twenty to twenty-five suckers in a year; but the more suckers it throws out the poorer will be the quality of the fruit. Four suckers may be allowed to remain—two to produce fruit during the current year, and two for the next year. The rest of the suckers should be removed and planted elsewhere or destroyed. Each sucker soon produces roots of its own and forms a complete plant. If the land is irrigated, transplantation can take place at any time of the year; otherwise it should only be done during the wet season. The most vigorous suckers should be allowed to remain with the mother-plant, care being taken not to injure them in removing the others.

Time of Ripening.

In the Canary Islands the young plants generally begin to bear fruit a year or eighteen months after being planted out. In French Guinea they bear earlier—at the end of eight or ten months. But the suckers left with the mother-plant will often

bear fruit when only four months old, if the land is irrigated and well supplied with chemical manures. The bunches must be supported by posts, otherwise the weight of the fruit is apt to bring down the plant. About sixty to eighty days intervene between the time of flowering and the ripening of the fruits. When ripe the bunches should be cut in the evening, put in an airy place for the night to sweat, and packed on the following morning. Plenty of bananas reach Europe during June, July, and August. Ripening may be retarded for a month or so by cutting off the extremity of the bunch with the sterile bracts, so that the bananas may come to Europe a month later, when there is more demand. A banana plant seldom yields good bunches in its first year, but in its second year will yield bunches worth exporting.

Intensive Cultivation.

The length of time during which a banana plantation may be maintained on the same land is a matter of some importance. A plantation may generally be carried on for about fifteen years, and when rotation of crops is possible this period may be considerably extended. The banana is a crop that exhausts the soil. In Central America, where the soil is rich, but where manuring is little practised, the planters find it necessary to displace their plantations from time to time, owing to the fact that the bananas remove from the soil the principal nutritive constituents, such as nitrogenous substances, phosphates, and potassium salts. It is estimated that the removal of the bunches of bananas from a plantation represents an annual loss per acre from the soil of 495 lb. of nitrogen, 110 lb. of phosphoric acid, 1,056 lb. of potassium and sodium, and 110 lb. of lime. Some of the compounds containing these substances in the soil are readily soluble and soon disappear, while those which are comparatively insoluble take some time to become soluble and of service to the plant. Where "extensive" cultivation is practised the area is too large to permit thorough application of manures, as the cost would be excessive. In French Guinea and the Canary Islands the soil is generally poor and requires manure. An "intensive" system of culture on a small area pays best.

PINEAPPLES.

Pineapples may be grown on the banana estates, provided that the two crops are not too closely mingled with each other.

Varieties.

The varieties of pineapple grown in French Guinea are: "Abacaxi or Pernambuco," "West Indian," "Armand Gautier," "Baroness de Rothschild," "prickly Camayenne," "smooth-leaved Camayenne," "Comte de Paris," "Enville or Sugarloaf," "Montserrat," "Princess of Russia," and "Providence."

Propagation.

Pineapples are propagated from suckers in much the same way as bananas, except that the suckers are derived from the axils of the leaves and from the base of the fruit. The crown is usually still on the fruit when it comes into the market, as dealers prefer it in that form. But this is a very wasteful custom, and the crown ought to be cut off on the plantation and used for purposes of propagation, as it forms the most vigorous of the young plants.

Three or four suckers may be produced by a plant in the axils of its leaves. The strongest sucker, particularly if it is the nearest to the ground, is allowed to remain, and the rest are either planted out direct on the estate, or placed temporarily in a nursery. The latter course is preferable, and may be effected in November or March. The young plants soon recover from the first move, and put out several roots, and are then ready to be transferred to their permanent place in the plantation, transplantation taking place during the wet season. When flowering has terminated, and the fruit is in process of formation, some of the suckers must be removed in order that the strength of the plant may not be withdrawn from the fruit. Care of the plants is necessary, as, having a small stem, they become top-heavy with the weight of the fruit, and the whole plant falls over on one side, exposing the roots. Such plants need to be propped. Ripening usually occurs in the dry season, about twelve to fifteen months from the beginning of propagation. Fruits

gathered during the dry season are of better flavour than those gathered during the wet season.

SOILS AND MANURES.

Pineapples are not at all exacting as regards the kind of soil in which they will grow, and, like bananas, flourish in a great variety of soils. The quality of the fruit varies with the soil, the best results being obtained in a soil rich in humus. The plant will stand a good deal of drought, but the fruits are larger and of better flavour when grown in a soil containing or supplied with a moderate amount of water during the dry season. On the other hand, the soil must not be one which becomes too sodden during the wet season. Good results have been obtained in French Guinea by the application of chemical manures to crops of pineapples, and the yield has been thereby greatly improved. In manuring, two principles are to be kept in view. One is to give the land the materials in which it is deficient, and the other is to supply the materials which the plant exhausts from the soil. The first may be described as manure of amelioration, the second as manure of maintenance. It is impossible to lay down hard and fast rules as to the manures which should be applied, partly because the physiology of plants and the chemical processes occurring in the soil have not been as yet sufficiently investigated, and partly because a manure required in one place is not necessarily required in another. The soil of French Guinea, derived chiefly from primitive rocks and laterite, is poor in phosphates and very poor in lime. The approximate proportions in which the various chemical constituents should be present in order to ensure fertility are sufficiently well known. What is necessary is that planters should ascertain experimentally the needs of the particular soils on their own plantations. They will then know what constituents are wanting. As an instance it may be mentioned that analysis of a soil in a district in French Guinea showed that to bring the proportion of lime to a proper percentage, two hundred tons of lime per acre were required, as the soil contained practically none. There is a serious want of lime in several parts of the West Coast of Africa, and many of the soils are very deficient in phosphates. It would be fortunate if dis-

coveries could be made of natural beds of phosphates with which the land could be enriched. Nitrogenous substances in the form of humus are fairly plentiful. The reserve of organic matter may be increased, where it is deficient, by green manuring with leguminous crops such as "ground-nut," "bersem," and "vigna catjang." In applying chemical manures to replace the loss of substances removed by the crop, allowance must be made for the incidental losses of chemical constituents through filtration and other processes occurring in the soil. Three principles must be observed—(1) fruit formation should be retarded during the wet season, when cropping and transit are difficult; (2) application of manure during the wet season is almost entirely wasted; (3) chemical manures must be applied gradually to ensure their producing the maximum effect.

PACKING.

Bananas.—The bunches are carefully brushed, enveloped in cotton wool, then in dry paper, and placed in open octagonal wooden crates which freely admit air. The bottom of the crate is lined with hay, straw, maize leaves or banana leaves cut up and dried. Empty spaces are firmly stuffed to prevent oscillation in transit.

Pineapples.—These are packed in a very similar manner. The method adopted in the Azores may be briefly described as follows:—The stem is cut below the fruit, when the latter is beginning to turn yellow and the top is still green. Each fruit is wrapped in soft paper, and six to eighteen fruits, according to size, are placed in one crate, which is lined with a layer of a kind of chaff of chopped-up maize leaves. In a crate containing eight, four are placed one in each corner and the other four in the centre, taking care to cross them, so that the crown of one is side by side with the stem of the other, with a small space between adjacent fruits. Crevices are thoroughly stuffed with maize chaff, and the same material is spread over all the fruits, and the whole firmly packed to prevent oscillation. Fruits must not project from the case, as the pressure would cause them to rot. They must on no account be bruised in picking or during packing. They should never be packed

immediately after being picked, but should first be allowed to cool for one night.

MALLET-BARK: A NEW AUSTRALIAN TANNING MATERIAL.

In recent years great progress has been made in several of the Australian States in the cultivation and utilisation of the wattle-barks derived from various species of Acacia. Large quantities of these barks are used in South Australia, New South Wales, and Victoria for tanning sheep-skins, and much of the leather so produced as well as large quantities of the barks are annually exported to the United Kingdom and the European continent.

Attention was directed in the *Imperial Institute Bulletin* (Vol. ii., page 226) to the fact that the utilisation of bark derived from the mangrove trees found along the coast of Queensland has already interfered to some extent with the import of wattle-bark into that Colony from other States of the Australian Commonwealth, and it appears that quite recently another product has been found which is likely to compete to some extent with wattle-bark for the trade in tanning materials between Australia and Europe. This new tanning material is derived from *Eucalyptus occidentalis* and is known in commerce as "Mallet-bark." Some information regarding this product has been published recently in German technical journals and also by Mr. E. M. Holmes in the *Pharmaceutical Journal* for February 4th of the present year.

The bark, which is of medium thickness, is very hard and shows a cinnamon-brown colour; it contains as a rule from 35 to 45 and occasionally up to 50 per cent. of a readily-soluble, yellow-brown tannin, which yields a firm, tough, light brown leather, quite free from the pink colour characteristic of leather tanned with wattle-bark. During 1903 about 500 tons of the bark were utilised locally in Albany and Fremantle, but none was exported till early in 1904, when consignments were sold

in Hamburg at prices ranging from £12 10*s*. 0*d*. per ton for unground to £13 10*s*. 0*d*. per ton for ground bark. During 1904 a total of 4,000 to 5,000 tons was collected, and the production for the present year, it is estimated, will reach 50,000 tons. The bark is greatly in demand in Continental tanneries, where it is used alone or in conjunction with valonia for medium-weight leather, and is also being used to a considerable extent in this country.

The cultivation of wattle-bark has also been rapidly developed in Natal, whence large quantities are now annually shipped to the United Kingdom. It is interesting to note that *Eucalyptus occidentalis* has been largely planted in Natal, and that consequently this Colony is also likely to become a producer of "Mallet-bark."

RECENT ADVANCES IN INDUSTRIAL APPLICATIONS OF ELECTRO-CHEMISTRY.

THE number of electro-chemical industries is comparatively small: the largest is that of copper refining; the production of aluminium is moderately great, while the manufacture by electro-chemical methods of alkali, chlorates, bleaching powder, and calcium carbide is fairly considerable. Other electro-chemical manufactures, such as the production of sodium and other alkali metals, phosphorus, lead, nickel, zinc, organic substances, nitrates from air, carborundum, etc., are insignificant when compared with the large industries previously mentioned. Some interesting information on recent developments of the various branches of electro-chemical industry is given in the series of Cantor Lectures delivered by Mr. Bertram Blount before the Society of Arts, and reprinted in the Society's journal (1904, Vol. lii., pp. 743, 753, and 762), from which and other sources the following summary has been prepared.

Some of these industries are entirely dependent on electro-chemical methods; to these belong the production of calcium carbide, carborundum, and aluminium; others, such as the

manufacture of chlorates, alkali, bleaching powder, etc., may be carried out by purely chemical methods, the chief consideration in the latter case being the relative cost of the method employed.

Electro-chemical processes may be arbitrarily classed according to the methods used, in the following way :—

(1) Winning and refining of metals in aqueous solution.

(2) Preparation of metals from fused electrolytes.

(3) Production of materials by means of the electric furnace.

(4) Preparation of alkali, bleaching powder, chlorates, and allied products.

(5) Manufacture of organic chemicals.

COPPER REFINING.—Probably about 70 per cent. of the world's production of copper is now refined electrolytically. In the United States alone 250,000 tons are refined annually, in this way yielding as bye-products 27,000,000 ozs. of silver and 346,000 ozs. of gold. The principle of copper refining by electrolysis is simple. Crude copper containing about 98 per cent. of the metal is cast into plates of a convenient size for handling, and these are used as anodes in an electrolyte of copper sulphate slightly acidified with sulphuric acid. The cathodes on which the copper is deposited in a pure state consist of thin sheet copper. The impurities—gold, silver, antimony, arsenic, bismuth, etc.—fall to the bottom of the depositing tanks or into nets surrounding the anode, as a sludge, which is worked up for its valuable constituents.

REDUCTION OF COPPER FROM ITS ORES.—Many attempts have been made to find an electro-chemical method of winning copper from its ores or the mattes produced in the preliminary smelting operations, but so far these have proved unsuccessful.

The most promising effort yet made in this direction is due to a copper smelting company at Dorchester in Canada, where the ore is a favourable one for extraction by such means, consisting as it does of a partially-weathered sulphide ore, in which the copper is largely present as a basic carbonate. It contains about 2·4 per cent. of copper, and has a siliceous gangue which is almost entirely insoluble.

The ore is roasted in revolving calciners, then "leached" with a 5 per cent. solution of sulphuric acid, and electrolysed, using lead anodes. Sulphurous acid is pumped into the vats to prevent

the formation of lead peroxide at the anode, and by its oxidation supplies the loss of sulphuric acid incurred. The content of copper in the ore is reduced from 2·5 to 1 per cent., and the electrolyte is then used again for "leaching" fresh portions of roasted ore. The metal produced is stated to be equal to the best brands of electrolytically refined copper.

REFINING OF ZINC.—The electrolytic refining of zinc is not largely practised, though numerous methods have been devised, since zinc of sufficient purity can be obtained by the cheaper distillation methods. On *primâ facie* grounds an electrolytic process should be successful, as the large amount of energy required can be economically and directly applied.

Three methods are available:—(1) winning of zinc from aqueous solution of a salt; (2) electrolysis of a fused zinc salt, *e.g.* zinc chloride; (3) reduction of zinc oxide with carbon in an electric furnace.

The drawback to the first of these methods is the spongy nature of the deposit obtained, but this can be obviated to some extent by using strong solutions, *e.g.* a 10 per cent. solution of zinc sulphate. Zinc chloride is preferable to the sulphate, as it readily dissolves zinc hydroxide, and the solution may thus be made slightly basic without seriously affecting the deposition. Only one method is in use on a commercial scale, and this is Hoepfner's, which is worked in the north of England. The process used is based on the fact that zinc chloride can be prepared by the interaction of roasted zinc ore and carbon dioxide with calcium chloride. The chlorine produced in the electrolysis is recovered in a marketable form; about 1,000 tons of zinc are made per annum, and the corresponding quantity (3,000 tons) of bleaching powder is obtained as a bye-product.

WINNING AND REFINING OF NICKEL.—A few years ago electrolytic nickel was a commercial product, now it is doubtful whether any is prepared by electro-chemical methods. Many practical difficulties are found in attempting to produce electrolytic nickel, the chief being the tendency of nickel to curl up from the cathode, and the difficulty of separating it from other metals, especially copper, which occur with it.

The first serious attempt was made at Swansea, where a copper-nickel matte containing 40 per cent. of nickel and 60

per cent. of copper was used, but the process failed in practice, owing, it is stated, to the incomplete separation of the copper. Another notable attempt was made at New Jersey, United States of America, in 1894, the process so far as is known being that of refining crude nickel containing from 96 to 97 per cent. of the metal. The attempt was discontinued in 1900. At Cleveland, Ohio, the electrolytic separation of nickel and copper has been attempted, by a process devised by D. H. Browne, on the same principle as that used in the Swansea experiments, using a chloride as the electrolyte. A crude metal containing about 43 per cent. of nickel and 51 per cent. of copper, the remainder being chiefly iron and some sulphur, is cast partly into anodes and partly into shot to supply the electrolyte, the latter being a mixture of nickel, cuprous, ferrous and sodium chlorides. The electrolyte passes into tanks where both nickel and copper are dissolved, and the latter is again deposited on cathodes of thin sheet copper sufficiently coherent to be handled and smelted again. The proportion of copper is by this means reduced to 1·25 per cent.: this remaining impurity is then precipitated as sulphide. The iron is removed by means of caustic soda and chlorine, and the purified solution of nickel and sodium chlorides is evaporated until the latter crystallises out. The solution of nickel chloride is then run into depositing vats containing nickel cathodes and graphite anodes, the latter being enclosed in clay cylinders to prevent the chlorine evolved from straying to the cathodes. The chlorine is again used for extracting fresh copper-nickel matte, and the weak liquor after deposition of most of the nickel is again concentrated. The nickel obtained is stated to be very pure. The Frasch process, tried at Hamilton, Ontario, consists in dissolving a copper-nickel matte by means of the chlorine generated in the anode cell in which sodium chloride is electrolysed, but the difficulties already referred to also occur with this method.

Mr. Titus Ulke has designed a process for use at Sault Sainte Marie for a daily output of 75 tons of copper and 7·5 tons of nickel. The anodes are prepared from Lake Superior and Sudbury ores, smelted to contain 88 per cent. of nickel. No details are available as to the method used.

WINNING AND REFINING OF LEAD.—The refining of lead

by metallurgical methods, such as the Pattinson and Parkes process, is carried out so perfectly that an electrolytic process can only be of advantage if the cost of production by such a method is less than that of the metallurgical process.

An interesting electrolytic process of refining devised by Mr. Betts is, however, used at Trail, British Columbia. The anodes consist of lead containing as much as 300 ozs. of silver and 3 ozs. of gold. The electrolyte is lead fluosilicate prepared by running hydrofluoric acid through a tank filled with quartz and dissolving white lead in the hydrofluosilicate produced. The chief merit of such an electrolyte is its solubility and the fact that it yields compact deposits of lead. The originator of the process states that the cost is no greater than that of the Parkes process.

A process for reducing lead from galena is in use at Niagara Falls. The crushed ore is placed on a number of shallow lead trays piled one above the other and insulated from each other by rubber sheaths. The trays are arranged in series, the bottom of each being the anode, and the galena on the one below, the cathode. The electrolyte is sulphuric acid. The ore is reduced to spongy lead, which is then roasted to litharge; the sulphur is evolved as hydrogen sulphide and burnt, and may be utilised, if required, for the production of sulphuric acid.

PRODUCTION OF ALUMINIUM.—This is a typical example of a metal prepared solely by electro-chemical methods in a bath of a fused electrolyte. Aluminium needs for its production a great expenditure of energy; for this reason all ordinary metallurgical processes are inapplicable. There appears to be only one manufacturing process for the production of this metal, which consists in electrolysing an aluminium salt or oxide between a carbon anode and aluminium cathode in a bath kept hot by the electric current itself. The quality of the metal prepared depends on the purity of the alumina used as a crude material. At Larne, French bauxite, which is preferable to the Irish mineral, although it contains more ferric oxide, is used as a raw material from which, as a first step, a fairly pure alumina is prepared.

Practically the whole of the world's supply of aluminium is obtained by reducing alumina in a bath of fused cryolite, fused

aluminium being periodically drawn off from the bottom of the depositing tanks and fresh alumina fed in at the top, the cryolite being unaffected at the voltage of the electric current used. The anodes consist of carbon blocks; the depositing tanks are made of iron, lined with carbon, on which rests an iron plate acting as the cathode.

PREPARATION OF SODIUM.—Many attempts have been made to produce sodium cheaply, but at present the demand for this metal is small, although its use for the manufacture of cyanide and sodium peroxide is steadily growing.

The well-known Castner electrolytic process is the only method worked on a manufacturing scale concerning which anything definite is known. It consists essentially in the electrolysis of caustic soda kept at a temperature slightly above its fusing point, so that the dissolution of the sodium by the caustic soda is at a minimum and the products of electrolysis are removed as fast as they are produced. The cathode consists of an iron rod surrounded by an iron ring acting as the anode, the sodium being collected in a cylinder of iron gauze over the top of the cathode, to prevent it straying to the anode compartment. It is periodically dipped off with a spoon of iron gauze, so that any soda taken up runs back again into the cell.

The Becker process is also stated to be used commercially, but on what scale is not known. It somewhat resembles the Castner process; the electrolyte is a mixture of caustic soda and sodium carbonate; the drawback of this process is the cost of the raw material. Sodium chloride, if it could be used, would be much cheaper and would yield the valuable bye-product chlorine.

The principal difficulties experienced in the manufacture of sodium from fused common salt is the high melting-point of the latter, and its corrosive action on the material of the vessel employed. Numerous processes, using salt, have been attempted and have failed, the most promising being that in which an alloy of sodium with some metal such as lead was formed; among the latter may be mentioned the Vautin process.

Another ingenious process worth mention has recently been devised by Ashcroft, in which the lead-sodium alloy produced by

the electrolysis of fused sodium chloride with fused lead as the cathode is circulated by an electro-magnet under the cell. This alloy is then used as the anode in a second cell in which the electrolyte is caustic soda, where sodium is transferred from the sodium-lead alloy to an iron cathode and can be collected as the metal.

ELECTROLYTIC MANUFACTURE OF ALKALI AND BLEACHING POWDER.—The successful processes may be divided into two classes: In one an intermediate electrode of mercury is used in an aqueous solution of sodium chloride, in the other the salt is fused and electrolysed with a cathode of molten lead. A typical example of the latter is the process mentioned under the production of sodium. The former is exemplified in the Castner-Kellner process used at Weston Point in America. The cell used in the former process is divided by a non-porous diaphragm dipping into a layer of mercury at the bottom, one compartment containing an aqueous solution of sodium chloride and a carbon anode, and the other water which is converted into caustic soda. The mercury acts as a cathode in the anode compartment containing the chloride, and carries the sodium to the other compartment where the alloy acts as an anode and gives up its sodium to a cathode of iron, and the sodium is then converted into caustic soda by the water present. Other types of cells are used which contain a porous diaphragm in place of the mercury, or which have no diaphragm. An example of the first is the Le Seur cell and of the latter the Bell cell.

The Hargreaves-Bird process carried on in the north of England is original. The cell has a diaphragm and cathode combined as one, copper gauze being closely attached to an asbestos sheet enclosing a compartment containing carbon anodes. Carbonic acid and steam are passed into a shallow chamber outside this diaphragm, and sodium carbonate is thus produced in this cathode compartment unmixed with brine.

MANUFACTURE OF CHLORATES AND HYPOCHLORITES.—Theoretically these compounds should be simple to prepare by the electrolysis of aqueous solutions of alkaline chlorides, by allowing the caustic alkali and chlorine formed to mix together, a hypochlorite being obtained at a low temperature, and a chlorate if the liquor is at or near its boiling-point. The principle has

been successfully applied in several ways. The procedure for hypochlorites is well adapted to paper works, where the hypochlorite can be used for bleaching the pulp and immediately returned to the bath for electrolysis again. In the preparation of bleaching fluids about 10 grams of available chlorine per litre is a working limit, although it is stated that in Germany liquors containing 20 grams of available chlorine per litre have been made.

The manufacture of potassium chlorate by electrolytic methods is said to be in a flourishing condition, but little is known of the details of the various processes used. As in the case of hypochlorites, the concentration must be kept low where the products of electrolysis are allowed to mix, but the liquor is kept near its boiling-point in order to prevent reduction at the cathode. Kellner has proposed the use of a small quantity of lime or magnesia dissolved and suspended in the liquor to hinder cathodic reduction.

CYANIDE GOLD EXTRACTION.—The electrolytic reduction of gold from weak cyanide solutions is of great industrial importance, since it has permitted the use of much weaker cyanide solutions of gold than is possible by the zinc dust precipitation process, at least in its original form. In the Siemens-Halske process the cyanide liquor is electrolysed between iron anodes and lead cathodes, the latter being cupelled when sufficient gold has been deposited on them. For the Andreoli process lead peroxide anodes and iron cathodes are used, the gold being stripped from the latter by dipping them in a bath of molten lead, which, when sufficiently rich in gold, is cupelled. By using aluminium cathodes, Cowper-Coles obtains gold sufficiently coherent to form a coating on the plates, which can be stripped off mechanically.

BARYTA.—A process is being tried at Niagara Falls for the production of baryta by electrolytic methods. It consists in heating heavy spar with carbon in what is really an electric furnace, whereby barium oxide and sulphide are obtained. The former is separated by throwing the mixture into water and crystallising out the barium hydroxide formed.

NITRATE FROM AIR.—A plant for the manufacture of nitrates from atmospheric nitrogen and oxygen was erected two years

ago at Niagara Falls. The air is burnt by drawing it through a large number of small arcs produced between platinum points on a vertical cylinder opposed to similar points on a revolving cylinder or spindle, into a tower supplied with caustic soda and a mixture of nitrate and nitrite obtained. The plant is said to yield 10 tons of nitrate of soda per year.

PREPARATION OF ORGANIC SUBSTANCES.—The application of electro-chemical methods to the preparation of organic substances has had a certain amount of industrial success. In general, electrolysis is used to carry out the processes of reduction and oxidation, particularly in the manufacture of dyes. The manufacture of iodoform by the electrolysis of potassium iodide in the presence of acetone or alcohol has been practised for some time. All the processes in use, however, may be said to be of a laboratory rather than a manufacturing type, and the amount of material produced in each case is comparatively small.

APPLICATIONS OF THE ELECTRIC FURNACE.

The application of the electric furnace for heating purposes can only be remunerative when ordinary fuel is excessively dear, and for the production of high temperatures unattainable by the combustion of ordinary fuels. Thus, calcium carbide and carborundum can only at present be produced in an electric furnace, but in the case of phosphorus the choice between a chemical method and one in which electric heating is used, is chiefly a matter of cost. There are two types of furnace, one in which the heat is generated by an arc, and the other containing a continuous core to act as a resistance. In practice the pure arc is never used. The efficiency of an electric furnace is fairly high, and is said by Richards to vary from 38 to 76·5 per cent., depending on the operation. All electric furnace products are comparatively simple, as complex bodies are broken down at the high temperature employed.

MANUFACTURE OF CALCIUM CARBIDE.—The largest application of the electric furnace is for the manufacture of calcium carbide, which is made by heating together lime and carbon, the latter usually in the form of coke, at the temperature of the electric arc.

Calcium carbide furnaces are of two kinds : in one the charge is fused and the product tapped, fresh raw material being fed in from time to time ; in the other, the product is not tapped, but starting with a small charge, a little pool of carbide is formed, and round this the raw materials are supplied, the electrodes being raised as the melted mass of carbide grows, till the vessel holding the charge is filled with a block of carbide. In general, the furnaces producing tapped carbide give the best product, but the block type is more economical of energy.

Carbide manufacture requires much power, and hence economy of this is one of the principal factors to be considered. Modern works are stated to produce $1\frac{1}{2}$ tons of carbide per horse-power year, while a year or two ago only 1 ton was obtained for the same expenditure of energy.

PREPARATION OF CARBORUNDUM.—This material, which is a carbide of silicon, is one of the most interesting products of the electric furnace. The furnace used for its production is of the resistance type, the current being conveyed by a moderately conductive core, the resulting heat being distributed to the surrounding charge.

The world's supply of this material is dependent on one or two works, that at Niagara Falls being probably the largest. The furnaces consist of a core of copper rods laid zig-zag with cross blocks bridging the angles of the zig-zag, round which is packed a charge consisting of 34 per cent. coke, 54 per cent. sand, 10 per cent. sawdust, and 2 per cent. of common salt (the two latter being used to keep the mass porous); the whole is supported in a brick box.

GRAPHITE.—At the Acheson works at Niagara Falls, graphite in blocks and in rods is produced. The furnaces are similar to those used for carborundum, having carbon electrodes, projecting into a brick box ; between these is a core which is to be filled with the product. The raw material is usually anthracite for mass or block graphite, and petroleum coke for rod or electrode graphite.

FUSED SILICA AND ALUMINA.—These products may also be prepared in the electric furnace ; the second of these rivals carborundum in hardness, while the former probably has a great future before it, as a new material for the construction of

retorts and other chemical vessels required for high temperature operations.

CARBON BISULPHIDE.—This compound is economically produced by internal local heating by electrical methods, and such a process has been worked at Penn Yan in the State of New York.

PHOSPHORUS.—The method employed in the manufacture of phosphorus by electrical heating is essentially the same as that used for carbon bisulphide. A charge of calcium phosphate, silica, and carbon, or of phosphoric acid and carbon, is packed round a resistance core, and then heated till the phosphorus is in a reduced state and the mass distilled.

IRON AND STEEL.—The preparation of iron and steel by electro-chemical methods is becoming of some importance. For some years attempts have been made to reduce iron ores economically in electrically-heated furnaces, but the process presents many difficulties when conducted on a manufacturing scale. The ordinary blast furnace again is fairly efficient, and pig iron is cheap, so that no electrical process using coal for the production of electrical energy could hope to compete with it, and the cheapest water-power would also have little chance even in a district where the ore and labour were cheap. The only prospect of success for such a process would be in a district where pig iron from the usual centres was kept out by prohibitive tariffs, or some other artificial barrier.

A furnace of the Siemens type, or of the Wilson carbide type, where an arc is produced between the lower end of a vertical electrode and the fused charge below it, but considerably modified, would serve the purpose.

Keller has devised a furnace resembling that used for carbon bisulphide, the feeding and tapping of such a furnace being similar to that of the blast furnace. Ruthenberg has also invented an ingenious method for treating ores too finely divided for the blast furnace, in order to agglomerate them.

The production of steel and other iron alloys is more advanced as an electro-chemical art, the function of electrical furnaces in this case being to keep pig iron fused while being specially treated, foreign substances being thus absent. A typical furnace is that designed by Heroult, which in principle is a large shallow

Siemens furnace. Kjellin has designed a furnace which needs no electrodes, and Gin avoids the use of consumable electrodes by making the iron to be refined, act as a continuous resistance.

The commercial production of special iron alloys, such as ferro-silicon, ferro-manganese, ferro-chromium, ferro-tungsten, etc., by electrical methods, is now well understood. For the production of such highly refractory alloys electrical heating appears to be essential.

PRODUCTION OF ZINC IN THE ELECTRICAL FURNACE.—Zinc is a metal which could probably be prepared advantageously in the electric furnace (methods of reduction from aqueous solutions of zinc salts have already been described), as economy would be effected in heating the mixture of zinc oxide and carbon by this means.

One of the earliest electric furnaces for this purpose was devised by Cowles for the distillation of zinc, and the same principles would have to be embodied in any furnace devised for this purpose in the future. A furnace for the reduction and distillation of zinc would have a good chance of success, considering the large annual output of this metal.

PRODUCTION OF MANGANESE ORES IN INDIA.

THE exploitation of manganiferous ores in India shows remarkable progress. The industry was started scarcely a dozen years ago in the state of Vizianagram, and the production, which amounted to 3,130 tons of ore in 1893, rapidly increased to 87,126 tons in 1899, the year in which the rich deposits in the Central Provinces were discovered. In 1903 the total production in India was 171,800 tons, thus placing that country in the second rank amongst the countries producing ores of good quality.

The deposits in the Central Provinces, which already furnish a larger output than those in Vizianagram, consist also of ores of superior quality containing from 51 to 54 per cent. of man-

ganese, which is sufficient to enable them to bear the cost of transport by railway for 500 miles and freight to Europe or the United States of America.

The greatest production is in the district of Nagpur, but a few good deposits are worked in the neighbourhood of Bhandara and Balaghat. Exploration is going on in the district of Chhatisgarh as well as in the State of Jhabua (Central India), and mining is also being continued in Vizianagram.

The mines of Nizagapatam, which yield ores with a high percentage of phosphorus, that is to say, from 0·11 to 0·4 per cent., compete with Russian ores of similar quality.

The ores of Brazil now compete with those of India in the markets of Europe, as well as in America.

The Imperial Institute has recently received from the Director of the Geological Survey of India a large number of samples of manganese ores derived from deposits in various parts of the country, which are at present under examination in the Scientific and Technical Department.

THE SUPPLY OF PRECIOUS STONES.

In a pamphlet published recently by the Geological Survey of the United States, Mr. G. F. Kunz gives some interesting information regarding the world's production of gems and precious stones. From this publication the following particulars have been compiled.

DIAMONDS.

The diamond, the most important of the precious stones, occurs in three varieties: (1) "*ordinary*," in transparent crystals, usually with rounded faces and varying from colourless to various shades of yellow, rose, green, and blue; (2) "*bort*," in rounded forms with rough exterior and radiating or confused crystalline structure, and intermediate in character between ordinary and (3) "*carbonado carbon or black diamond*": the

hardness of this variety is as great or greater than ordinary diamond and it is less brittle. Black diamond alone is used to any extent industrially, and owing to the great demand which has arisen in recent years the price of this kind has increased threefold, and is now about equal to that obtained for the variety used as jewellery. The principal uses of the "carbonado" diamond are the preparation of the faces of rock drills, the manufacture of cutting machines, and the lining of dies for wire drawing. For this latter purpose stones weighing from 0·25 up to 25 carats are used.

South Africa.—The statistics of the production of diamonds in South Africa according to the reports of various companies for the year ending on the 30th June, 1903, showed general progress in all departments. The rock shafts in the De Beers and Kimberley Mines have now reached depths of 2,076 and 2,539 feet respectively, the lowest working levels being 1,480 and 1,920 feet respectively. The "Bultfontein" and "Premier" mines have not been opened to any greater depth than in 1902, the depths in these two cases being 600 and 500 feet respectively. The yield of diamonds per load of rock has increased in the "Bultfontein" mine from 0·21 to 0·24 carat, and in the "Premier" mine it remains at 0·30 carat.

The production in the principal mines is given in the following table for the year ending 30th June, 1902–3 :—

	Bultfontein.		Premier.		De Beers, Kimberley.	
	1902.	1903.	1902.	1903.	1902.	1903.
Loads of blue clay hoisted	353,042	318,410	1,932,140	1,987,543	2,062,459	2,370,503
Loads of blue clay washed	20,194	317,185	1,752,189	1,989,598	1,961,858	2,561,940
Diamonds found—(carats)	4,486	76,573	521,437	594,890	1,499,299	1,574,189
Diamonds found—(value)	£6,817	£118,102	£873,203	£1,021,276	£3,484,247	£3,819,653
Number of carats per load	0·21	0·24	0·30	0·30	0·76	06·1
Value per load . .	6*s*. 9*d*.	7*s*. 5*d*.	9*s*. 11*d*.	10*s*. 3*d*.	35*s*. 6*d*.	29*s*. 9*d*.
Value per carat . .	30*s*. 4*d*.	30*s*. 10*d*.	33*s*. 5*d*.	34*s*. 4*d*.	46*s*. 5*d*.	48*s*. 6*d*.
Cost of production per load	6*s*. 6*d*.	5*s*. 9*d*.	3*s*. 5*d*.	3*s*. 3*d*.	8*s*. 5*d*.	7*s*. 3*d*.

Brazil.—Diamonds were first discovered in Bahia in 1821, and their exploitation commenced in 1844. Fourteen mining districts are recognised, but these may be grouped into two well-marked geographical sections, one in the central part of the State in the basin of the Paraguaen River and its tributaries, and the other in the southern part along the valley of the Pardo River. The Brazilian production has declined considerably in recent years owing to the competition with the South African mines, which are better organised and more systematically developed. The chief centre of production in the Paraguaçu River district lies about 250 miles from the city of Bahia, but diamonds begin to occur in the bed of this river about 150 miles from the coast, and continue to be found as far as Andarahy, a distance of about 172 miles with a width varying from a minimum of three or four miles to a maximum of sixteen miles. The most productive region is apparently that of the foot hills east of the Serra das Lavras Diamantinas along the small tributaries of the Paraguaçu. The geology of the region is described by Mr. Furniss, United States Consul at Bahia, as consisting of granitic hills with much sandstone and conglomerates. The granite shows a slightly inclined stratification, and is probably a gneiss. This rock is frequently broken by gullies, fissures, or crevasses, which are in many cases filled with sandstone and conglomerates, and these latter also occupy small basins in the crystalline rock: all being much weathered. The "ordinary diamond" and "carbonados" occur in the fragmental rocks.

The methods in use in Brazil consist in digging out the diamond gravel and storing it up until the rainy season sets in. Sometimes water is conducted through native-made sluices to the heaps. The cleaned gravel so obtained is further washed in troughs, and the diamonds picked out by hand. Some five thousand people are engaged in the operations, and they work irregularly, using primitive tools. The price of Brazilian "carbonados" has increased from $4 in 1894 to $11 per carat in 1902, due, as already stated, to the increased demand for them in the manufacture of mining and drilling machinery. The present output averages 2,500 carats a month, but the deposit is immense and the output is only limited by defective

methods of working. The largest "carbon" or "black diamond" yet found weighed 3,150 carats, and was obtained in 1895.

British Guiana.—In the year ending 30th June, 1902, the number of diamonds declared as found in this Colony was 132,077, nearly all from the Mazaruni district. The British Guiana diamonds are said to resemble those from Diamantina, Brazil, though they are generally of small size. Plans are under consideration by the Government for opening a road from Potaro to the still water above the Mazaruni Falls, which is already traversed by a steam launch, or to make the connection by means of a railroad. In 1902 the quantity of diamonds produced amounted to 11,718 carats.

Borneo.—Diamonds exist in the south-western part of the island in the region of the Landak River, near the mouth of the Seran River. A piece of so-called serpentine has been obtained there which encloses a diamond in what appears to be its true matrix. Diamonds are also said to exist along the tributaries of the Barito River.

New South Wales.—Within the last few years extensive discoveries of diamonds have been made in this Colony, but the diamonds, though brilliant and remarkably hard, are all small, and the output is not yet of great importance. The modes of occurrence in this region are interesting. The mining district is fairly extensive, and the principal centres are located in the counties of Shardinge and Murchison. The diamonds are found with gold, stream tin, and various other minerals, in old gravel beds, which have been covered and protected from erosion by flows of tertiary basalt, and occasionally the gravel is cemented by iron oxide into a sort of conglomerate, but there is no indication of the original source of the diamonds. At one or two points, however, they have been traced to outcrops of a volcanic breccia closely resembling the African formation. A most interesting occurrence has been described by Mr. Card, of the Geological Survey, of diamonds existing in an eclogite breccia in the Bingara diamond mines. This breccia bears a close resemblance to the diamond-bearing rock at Kimberley, and, like it, occupies a vertical pipe piercing through sedimentary beds, and itself occurs in boulders and fragments in the intruded basalt and largely in this breccia, from which it may have been

taken up by the basalt. The breccia consists of various-sized pieces of melaphyre, claystone and eclogite embedded in a granular mass composed largely of minerals liberated by the decomposition of the eclogite.

India.—The diamond-producing fields in India may be divided roughly into three sections :—Southern : consisting of Golconda or Telingana, including the five modern mining districts of Cuddapah, Kurnul, Bellary, Krishma, and Godavari. (2) Middle : constituted by the large tracts of country between the rivers Godavari and Mahanadi. In this section diamonds are still found near Sambalpur and Warragarh, and occasionally in two or three localities in Chota-Nagpur. (3) Northern : including Bundelkhand, where diamonds are regularly mined in the district of Panna.

In Northern India diamonds occur in the Rewah group of the Upper Vindyan formation, and in the Madras Presidency in the Kurnul formation.

SAPPHIRES.

Queensland.—The sapphire-bearing deposits of Queensland have been known for over twenty years, but have only lately begun to attract attention. The deposits occur in an ancient alluvium belonging to old stream gravels, and run parallel to the present watercourse. The gravel consists largely of decomposed basalt which has been protected by boulders and masses of a hard siliceous rock of cretaceous age. The sapphires themselves occur in a variety of crystalline forms in many shades and hues of colour, but not in the deep blues and reds most prized as jewellery. Greens, yellows, and light blues showing strong dichroism are frequent. The sapphires are obtained by mechanical separation in much the same way as gold, sieves being used instead of washing-pans. The coarser gravel and the fine material are thus removed either by washing or jigging, according as water is accessible or not, and the smaller gravel picked over by hand for the gems. The amount realised by the sale of sapphires up to 1902 was about £10,000.

RUBIES.

Burma.—Rubies are at present the only important gem product of India, and their occurrence is confined to Upper Burma. In the Mogok Valley the Burma Ruby Mining Company produced 210,784 carats of rubies, 9,786 carats of sapphires, and 10,241 carats of spinels in 1902.

The "byon," or gem gravel, is worked to a depth of 50 feet, then crushed in rotary pans, and the gems finally separated by "pulsators" and hand-picking. The estimated value of rubies sold annually in Mandalay amounts to 30 lakhs of rupees.

Borneo.—Fragments of ruby and sapphire have been found in the eastern part of the island.

JADE (NEPHRITE).

New Zealand.—The location of a vein of jade (greenstone) at Milford Sound, New Zealand, has resulted in the organisation of a mining company to work this material. Previously the greenstone was found only in rolled pebbles or boulders. The material has been extensively shipped to Europe and China, and there appears to be a small market for the output.

This gemstone has also been found in German New Guinea.

SPODUMENE.

This material has long been known to mineralogists, but only within recent years has it been ranked among gem minerals. It is a double silicate of aluminium and lithium, is rather complex in constitution and peculiarly liable to alteration, the first effect of which is to destroy its transparency.

Transparent crystals have been found in New England, U.S.A.; Minas Gereas, Brazil; San Diego Co., California; and Alexander Co., N. Carolina.

A blue-coloured, transparent spodumene showing strong dichroism and a continued phosphorescence after being subjected to ultraviolet light, has been called "*kunzite.*" It has been worked since 1903, and yields a remarkably brilliant gem. Its colour is generally pink or violet, and is almost unique. The price ranges from 6 to 20 dollars per carat.

DIATOMACEOUS EARTHS (KIESELGUHR) AND THEIR UTILISATION.

THE natural deposits of silica of organic origin which are of most importance commercially are those which are formed in fresh or brackish water by the accumulation of the siliceous cases or "frustules" of the minute plants known as diatoms belonging to the order Diatomaceæ (Bacillariaceæ). Each plant consists of a single grey or brown cell, and seldom measures more than one two-hundredth of an inch in diameter, while many are very much smaller. The siliceous case in which it is enclosed consists of two shells fitting one into the other like a box and its lid. They vary considerably in shape, but usually taper towards each end. They multiply with great rapidity and form a scum on the water, either floating free or attached to foreign objects. When the organism dies it sinks to the bottom, where the siliceous shells accumulate in combination with a certain proportion of decomposed vegetable matter. With them are also found the siliceous spicules of fresh-water sponges. These deposits are in many cases associated with volcanic materials, which no doubt furnish silica to the water from which the diatoms extract it to build up their siliceous envelopes.

Diatoms also live in the sea, and on certain portions of the ocean floor there are accumulations of ooze containing a large proportion of organic silica derived from the frustules of diatoms, sponge spicules, and the skeletons of radiolaria (organisms referred to the animal kingdom). These marine deposits have in some cases been raised above the sea-level, but have rarely been put to the same economic uses as the fresh-water beds.

The softer diatomaceous deposits are known in England as diatomaceous earth, though the German name kieselguhr is now also in common use. The term "infusorial earth" is sometimes used: this is objectionable, as the minute animals known as infusoria have no share in the formation of the deposits. These earths are usually of comparatively recent formation, and occur in peat-bogs or marshes on the margin of existing lakes or on the sites of those that have been filled up or drained.

Diatomaceous earth is a mealy powder of very friable rock resembling chalk or clay. The colour varies between different shades of white, yellow, grey, or brown.

Older deposits of a similar character are found in tertiary rocks associated with lignite or brown coal. They are usually more consolidated, and are known as polishing shale (polirschiefer) or tripoli, from its occurrence at Oran in Tripoli.

The word diatomite may be employed as a comprehensive term for all materials formed mainly of diatoms.

The silica of diatomaceous deposits being of organic origin differs in its characters from ordinary crystalline silica or quartz. It has a lower specific gravity and less hardness, and contains a considerable amount of water. It is, in fact, a variety of opal. Like other opal, it differs from quartz in being soluble in a solution of sodium carbonate. Silica soluble in this medium is known as "soluble silica," and its amount forms a valuable indication of the quantity of organic silica present. It must be remembered, however, that in course of time opal is apt to lose water and crystallise out as quartz, at the same time ceasing to be soluble. The proportion of soluble silica may, on the other hand, be increased by depositions of opal between the minute shells; this diminishes the value of the material for commercial purposes. There is another crystalline form of silica known as tridymite, which is soluble in a solution of sodium carbonate; it only occurs in volcanic rocks.

The Economic Applications of Diatomite.

The applications of diatomite depend on its possession of the following qualities :—abrasive power, absorptive capacity, and imperfect conduction of heat. Its value is considerably increased by calcination which removes the organic material and water.

In power of abrasion it is very inferior to corundum and emery, but it works much more uniformly on account of its minuteness of grain, and leaves a polished surface without visible scratches. Preparations of diatomite are widely used, often under fancy names, for polishing delicate metal work and objects of a similar nature. Some brands of soap which are intended as substitutes for pumice also contain diatomaceous material.

The power of absorption which diatomaceous earth and, in a

less degree, tripoli possess is a result of the large amount of air space which is included in them, and which may amount to as much as 85 per cent. of the whole volume.

When diatomaceous earth, or kieselguhr, as it is usually called in this connection, is saturated with nitroglycerine it forms the explosive known as dynamite. The latter is, however, now to a large extent replaced as an explosive by combinations of nitroglycerine and nitrocellulose, which are at once more powerful and safer.

The value of diatomite as a non-conductor of heat is, like the absorptive power, dependent on the air it contains, but while only so much of the air space as can be filled with liquid is of any service for absorption, space completely enclosed such as that in the interior of sponge spicules contributes to the non-conductivity of the material.

Diatomite has the advantage over many non-conductors such as cork of being unaffected by comparatively high temperatures, and over others such as mica and the various mineral products known commercially as "asbestos" in its lightness. It is also fairly cheap.

As a non-conductor it has been employed for filling the hollow interiors of the walls and doors of safes and fireproof rooms, as a lining for stoves, fire-places, and blast furnaces, and as a cover for the hot-air pipes connected with the latter; also as jackets and settings for boilers and covers for steampipes.

For these purposes it is sometimes convenient to form the material into bricks, slates, or other shapes. Intense heat will effect a certain amount of consolidation, but it is usual to add lime, alkalis, or clay with this object. Some experiments on the manufacture of such bricks were made by Mr. G. C. Hoffmann on material from Pollet River Lake, New Brunswick (*Geological and Natural History Survey of Canada, Report of Progress*, 1879–80 (1881), *Report H.*, p. 3). For the analysis of the material experimented on, see below (page 97).

Five classes of bricks were made, the 1st with the diatomaceous earth alone, the 2nd and 3rd with 5 and 10 per cent. of clay, and the 4th and 5th with 1 and 2 per cent. of lime respectively. They were carefully dried and burnt, being ultimately raised to a white heat. They showed no sign of fusion. Though highly

absorbent they were very firm and tough; but those formed with clay possessed these qualities to a rather less degree than the others, and they decrepitated when suddenly exposed to an intense heat. This decrepitation also occurred with the bricks moulded from the earth alone, but not with those containing lime. None of the bricks, however, suffered in this way when the heat was gradually applied. The bricks containing clay contracted to the extent of 11·18 per cent. of the original size; those without admixture 9·87 per cent., and those with lime 9·20 per cent. and 7·89 per cent. respectively. Previous to fusing, all the bricks were white, a colour which was retained by those mixed with lime, while the others became cream-coloured.

From every point of view the admixture with lime appeared to give better results than that with clay. All the bricks showed a high degree of non-conductivity for heat.

Mixtures of diatomite with clay have been used for brick-making in the north of Ireland, and with fireclay at the Bulla Tile works in New South Wales and in Victoria. The Australian bricks shrunk enormously on prolonged use in furnaces, and the manufacture was abandoned (G. W. Card and W. S. Dun, *Records of the Geological Survey of New South Wales*, Vol. v., 1897, p. 135).

Diatomite has also been used experimentally in the manufacture of porous pottery and so-called artificial meerschaum.

It has been suggested that diatomite should be used in the construction of the walls of cold storage rooms or cold transport wagons, and a so-called "refrigerating paint" appears to have been manufactured in Australia for the purpose, but it is improbable that a mere layer of paint would be thick enough to be of much use for excluding heat. The lightness and incombustible character of diatomite appears to make it suitable in certain cases for use in building construction, especially in the roofs of houses in hot countries. For this and other purposes the facility with which it absorbs water is a serious difficulty. Either it must be enclosed in a casing impervious to water, or the outside of each brick or slab of the diatomite must be rendered waterproof by means of a varnish or enamel, preferably the latter. This would also diminish its friability, which is a serious disadvantage in a situation where there is much movement or vibration.

Diatomite would probably prove to be an efficient insulator for electrical purposes, but no experiments appear to have been made in this direction.

Diatomaceous earth has—on account of its easy solubility in alkalis—been employed in the manufacture of silicate of soda or water glass and of ultramarine, and it has also been applied in various ways as a fire-proof material (Eng. Pats. 1432, 1883 and 9803, 1884). A composition is manufactured in Germany containing a mixture of diatomite with asbestos or hair, which is intended to be applied to many of the purposes indicated above.

Some interesting "Notes on Kieselguhr and its technical applications" by Haacke will be found in the *Journal of the Society of Chemical Industry*, 1884, Vol. iii., p. 132.

Distribution of Diatomite.

Diatomaceous deposits occur in numerous localities throughout the world. A large number of these are referred to in Zirkel's *Lehrbuch der Petrographie*, Vol. iii., pp. 556–61, and Rosenbusch's *Elemente der Gesteinslehre*, pp. 412–13. Such deposits are especially common in Northern Europe, and in mountainous regions further south.

The principal source of diatomaceous earth or kieselguhr in Europe at present are the deposits at Oberohe, near Ebsdorf, in the Lüneburger Heide in Prussia. They are covered only by thin surface deposits, and extend downwards to a depth of about 150 feet. The upper stratum supplies white kieselguhr containing very little organic matter but some sand. When washed it yields a pure and very porous product. The next stratum consists of grey kieselguhr with little sand. It contains sufficient organic matter for calcination to be carried out without extraneous fuel, and the product is said to be of fine quality, and has been largely used for dynamite manufacture. The lowest and by far the largest stratum varies from 50 to 100 feet in thickness and yields green kieselguhr, which sometimes contains as much as 30 per cent. of organic matter. The green kieselguhr is dried and then calcined in kilns, which are simple round furnaces about 15 feet high by 6 feet in diameter. When full the charge is kindled at the bottom and no additional fuel is required. The calcined material is removed from the grates

below and fresh green kieselguhr added at the top. The product is free from moisture and non-siliceous organic matter, but contains a little iron which gives it a reddish colour (Haacke, *loc. cit.*).

A sample of kieselguhr from Oberohe was analysed with the following results (Rosenbusch, *loc. cit.*) :—

		Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	87·86	98·20
Alumina	Al_2O_3	0·13	0·15
Ferric Oxide	Fe_2O_3	0·73	0·82
Lime	CaO	0·42	0·47
Carbonic Acid	CO_2	0·33	0·37
Water	H_2O	8·43	—
Non-siliceous organic matter		2·28	—

Important deposits occur in the immediate neighbourhood of Berlin. The kieselguhr of Tütelwiese, near Tiefwerder, Spandau, has the following composition :—

			Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	(Soluble)	34·39 } 63·36	39·85 } 73·43
,,		(Insoluble)	28·97	33·57
Alumina	Al_2O_3		4·92	5·70
Ferric Oxide	Fe_2O_3		14·71	17·05
Lime	CaO	}		
Potash	K_2O	}	3·30	3·82
Soda	Na_2O	}		
Water and non-siliceous organic material.	Loss on ignition.		13·71	—

An important deposit of tripoli occurs at the south-west end of the Tripelberg, Kutschlin, near Bilin, Bohemia, where the lower layers are infiltrated with opal so as to be quite hard.

Specimens from these deposits were analysed with the following results :—

		White Upper Bed.		Lower Opalised Bed.	
		Raw Material. Per cent.	*Ignited Material calculated).* Per cent.	*Raw Material.* Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	74·20	90·78	80·30	92·44
Alumina Ferric Oxide	Al_2O_3 Fe_2O_3	6·81	8·33	5·40	6·22
Magnesia	MgO	—	—	0·43	0·49
Lime	CaO	0·41	0·50	0·44	0·51
Potash	K_2O	0·02	0·02	0·30	0·35
Soda	Na_2O	0·30	0·39	trace	trace
Water	H_2O	13·30	—	10·90	—
Non-siliceous organic material		4·20	—	1·30	—
Sulphuric Acid	SO_3	0·12	—	—	—
Phosphoric Acid	P_2O_5	0·24	—	—	—
Ammonia	NH_3	0·03	—	—	—

Diatomaceous earth is of frequent occurrence in Scotland. It is usually found beneath a layer of peat. When freshly exposed it has a brown, sometimes greenish colour, but after drying in the air it acquires a buff or grey tint.

It is estimated that in Black Moss, north-east of Loch Kinnord in Aberdeenshire, there are 800,000 cubic yards of the crude material, which would yield 150,000 tons of dried diatomaceous earth. It occurs in at least an equal amount at Kinnord and Ordie, and has been met with at Drum, Auchnerran, Dinnet, and Press-when, all in the same county.

The following are the results of analyses of good samples from the Black Moss and Ordie Moss, Aberdeenshire:—

		Centre of Black Moss.		Ordie Moss.	
		Dried Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.	*Dried Raw Material.* Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	58·18	91·63	62·19	93·36
Alumina	Al_2O_3	0·40	0·63	0·41	0·62
Ferric Oxide	Fe_2O_3	0·91	1·43	1·90	2·85
Lime	CaO	2·39	3·77	1·05	1·58
Magnesia	MgO	0·86	1·36	0·56	0·83
Potash Soda	K_2O Na_2O	0·25	0·40	0·14	0·21
Sulphuric Acid	SO_3	0·23	0·37	0·16	0·24
Non-siliceous organic material		36·61	—	33·59	—

The Aberdeenshire deposits have long been worked for the manufacture of dynamite. The diatomaceous earth is calcined in kilns, as in Germany. The Black Moss, Kinnord, and Auchnerran earths resemble one another in containing fibrous stems of plants, so that slabs can be "cast" and stacked like peat to dry, which is a considerable advantage. In the Loch Kinnord deposit, nodular masses containing a large percentage of iron occur, which unless picked out before calcining gives trouble by fusing.

The island of Mull is another locality for diatomite. An analysis of the best quality from this place gave the following result:—

	Raw Material. Per cent.	Ignited Material (calculated). Per cent.
Silica . . . . SiO_2	78·57 {diatoms 75·25, sand 2·83}	85·73 {diatoms 82·62, sand 3·11}
Ferric Oxide . . . . Fe_2O_3	11·81	12·95
Lime . . . . CaO	1·19	1·30
Carbon Dioxide . . . CO_2	0·93	—
Non-siliceous organic material	5·07	—
Moisture . . . . . . —	2·42	—

Diatomite is found at Loch Osabhat, Tolsta, in Lewis. Loch Osabhat is a drained lake, covering an area of $1\frac{1}{2}$ acres. There is a thickness of some $7\frac{1}{2}$ feet of diatomaceous earth beneath 4 feet of peaty matter. About 7,500 cubic yards are available.

Diatomaceous earth is also met with at Golspie in Sutherlandshire, at Campbeltown, Strathcur, and Glenshira in Argyllshire, and at Loch Cuithir (Quire), Monkstadt, Mealt, Cleat, Sartie, and Glen Uig in Skye. Adjoining Loch Cuithir, which is a small tarn at the north end of the island, are 24 acres of swampy ground, where a layer of turf and peat 3 to 4 feet deep covers a deposit of diatomaceous earth, averaging 8 to 9 feet in thickness. In several places no bottom was found at a depth of 14 feet. Reckoning 6 cubic yards to the kiln-dried ton, there should be 72,000 tons available.

Two analyses of samples from Loch Cuithir gave the following results:—

	No. 1.		Centre.	
	Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.	*Raw Material.* Per cent.	*Ignited Material (calculated).* Per cent.
Silica . . . . . SiO_2	85·63	96·40	88·73	99·20
Ferric Oxide . Fe_2O_3	2·68	3·01	0·67	0·75
Lime . . . . . CaO	0·52	0·58	0·04	0·04
Non-siliceous organic material	4·25	—	4·15	—
Moisture	6·92	—	6·40	—

At Loch Monkstadt, to the north-west of Cuithir, the deposit covers about half a square mile. It is, however, interlaminated with sand and mud, and the diatomaceous earth itself contains sand grains and flakes of mica (W. Ivison Macadam, and J. S. Grant Wilson, *Mineralogical Magazine*, Vol. vi., p. 87; Vol. vii., pp. 30, 35; Vol. viii., p. 135).

Diatomite also occurs in Ireland in the counties of Antrim and Down on both sides of the river Bann from Toome Bridge to Coleraine, and is known as the Bann clay. It rests on peat or peaty clay, and is overlaid by thin soil. From Lough Beg to Port Glenone it is 4 to 5 feet thick; elsewhere it is thinner.

Its composition is as follows:—

	Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.
Silica . . . . SiO_2 { (Soluble) . (Insoluble)	15·89 } 57·12 } 73·01	85·00
Alumina . . . . Al_2O_3	8·55	9·95
Ferric Oxide . . . . Fe_2O_3	2·09	2·43
Magnesia . . . . MgO	0.83	0·96
Lime . . . . CaO	1·14	1·33
Potash . . . . K_2O } Soda . . . . Na_2O }	0·28	0·33
Non-siliceous organic matter } Combined water . . . }	7·71	—
Moisture	6·39	—

No diatomaceous deposit of any importance appears to have been described in England or Wales.

Diatomite occurs in lignites and peat beds in Canada. In New Brunswick it is found at Fitzgerald Lake, St. John's country, which has been drained, and Pollet River Lake in Mechanic Settlement, and Pleasure Lake, both in King's County, and on the Grand Manan Island. The deposit in Pollet River Lake averages 4 feet deep and is of good quality.

Analysis showed it to have the following composition :—

	Raw Material. Per cent.	Ignited Material (calculated). Per cent.
Silica . . . . . . SiO_2 (Soluble) .	78·68	92·33
(Insoluble)	1·81 } 80·49	2·12 } 94·45
Alumina . . . . Al_2O_3	3·15	3·69
Ferric Oxide . . . . Fe_2O_3	0·95	1·12
Magnesia . . . . MgO	0·28	0·33
Lime . . . . CaO	0·34	0·40
Carbonic Acid . . . . CO_2	0·01	0·01
Water and non-siliceous organic matter . .	13·32	—

Diatomite is worked in Nova Scotia at Folly Lake, Fountain Lake, and near Castlereagh, all in Cumberland County, as well as in the counties of Pictou, Cape Breton, Inverness, Colchester and Victoria, and other localities. The total output of the province in 1902 being 1,052 short tons of 2,000 lbs. It is also met with in the provinces of Quebec, Ontario, and British Columbia. In the last mentioned the most important locality at present known is at the head of Loon Lake. Here the material is fine grained and pale red in colour. It has been used by the Indians in making tobacco pipes. For other Canadian localities see an article on "Infusorial Earth," by E. D. Ingall, in the *Annual Report of the Section of Mines for* 1902, Vol. xv.

Numerous deposits of diatomite are met with in the United States. The best known is that of Richmond, Virginia, which extends from Herring Bay on the Chesapeake in Maryland to Petersburg in Virginia; it is sometimes 30 feet thick, and is then very impure. Other important deposits occur in the Western States.

Analyses of the United States diatomites :—

	Pope's Creek, Maryland.		Morris Co., New Jersey.		Lake Umbagog, New Hampshire.		Truckee R., Nevada.		Pinal Co., Arizona.	
	Raw. Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw.* Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw.* Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw.* Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw.* Per cent.	*Ignited Material (calctd.).* Per cent.
Silica . . SiO_2	81·53	86·81	80·66	94·81	80·53	91·72	91·43	94·64	82·81	90·70
Alumina. . Al_2O_3	3·43	3·65	3·84	4·51	5·89	6·71	2·89	2·98	4·84	5·30
Ferric Oxide Fe_2O_3	3·33	3·54	—	—	1·03	1·17	0·73	0·76	1·10	1·20
Lime . . . CaO	—	—	0·58	0·68	0·35	0·40	0·25	0·26	2·10	2·30
Magnesia . MgO							0·36	0·37	trace	—
Potash . . K_2O	5·63	5·99	—	—	—	—	0·32	0·33	—	—
Soda . . . Na_2O							0·63	0·65	0·24	0·26
Chlorine . . Cl	—	—	—	—	—	—	—	—	0·27	0·30
Water and non-siliceous organic matter	6·04	—	14·01	—	12·03	—	3·80	—	5·07	—

No organic matter is present in this material; the loss on ignition is due to moisture only.

A deposit from 2 to 30 feet thick, covered by 4 feet of water, in the White Lake near Wilmurt Herkimer, New York State, is worked in the following manner:—It is washed and run through strainers and pipes to settling vats. After it has been allowed to stand for twenty-four hours, the water is run off and the material is shovelled into a press which forms cakes 4 feet square and 4 inches thick. These are sub-divided into smaller cakes 1 foot square, which are piled under sheds to dry.

They have the following composition:—

		Per cent.
Silica . . .	SiO_2 .	86·52
Alumina . .	Al_2O_3 .	0·45
Ferric Oxide .	Fe_2O_3 .	0·37
Lime . . .	CaO .	0·12
Undetermined .	. . . .	0·42

Siliceous deposits of marine origin containing diatoms, radiolaria and sponge spicules are met with in the island of Barbados and have been mined and exported to a small extent. Diatomite is also stated to occur at Acangallo in Mexico, and near Arequipa in Peru and also in Chile.

Many diatomaceous deposits have been described from Australia.

The most important deposits in New South Wales are those in the Nandewar Range, Barraba district, Wantialable Creek,

Warrumbungle Mountains, Cooma, and on the Richmond River at Wyrallah, near Lismor.

The following results were obtained on analysis :—

	Cooma.		Richmond River, Wyrallah.		Wantialable, Warrumbungle Mts.		Nandewar Range, Barraba District.	
	Raw Material. Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw Material.* Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw Material.* Per cent.	*Ignited Material (calctd.).* Per cent.	*Raw Material.* Per cent.	*Ignited Material (calctd.).* Per cent.
Silica . . . . SiO_2	83·30	94·22	90·94	96·23	82·62	93·07	71·13	81·54
Alumina . . . Al_2O_3	3·84	4·34	2·38	2·52	5·20	5·86	13·06	14·97
Ferric Oxide . Fe_2O_3	0·36	0·41	0·86*	0·91*			0·91	1·04
Magnesia . . . MgO	0·36	0·41	trace	trace	trace	trace	0·87	1·00
Lime . . . . CaO	0·30	0·34	—	—	0·53	0·60	0·31	0·36
Carbon Dioxide. CO_2	—	—	—	—	0·42	0·47	0·95	1·09
Sodium Chloride $NaCl$	0·25	0·28	0·32	0·34	—	—	—	—
Combined water H_2O	5·84	—	2·79	—	3·08	—	4·03 *	—
Moisture	5·40	—	2·69	—	7·88	—	7·30	—

* Some of the iron in the Richmond sample was present as ferrous oxide, and the "combined water" in the sample from Barraba includes organic matter.

(See "The Diatomaceous Earth Deposits of New South Wales," by G. W. Card and W. S. Dun, *Records of the Geological Survey of New South Wales*, pp. 128–148 (1897), where a detailed list of the Australasian localities will be found.)

The Cooma and Wyrallah deposits occur in depressions in basalt, and in the latter case they are overlaid by the same rock. They have been consolidated by the deposition of opaline silica. This, though it increases their percentage of silica, diminishes their absorptive power and commercial value. The Warrumbungle deposits are interstratified with trachyte. The Barraba beds are covered by a sheet of basalt.

In Queensland diatomite occurs in a hill known as Meerschaum Hill, Pine Creek. The hill receives its name from the resemblance of the material to meerschaum. An analysis gave the following results :—

	Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.
Silica . . . . SiO_2	89·10	99·34
Alumina . . . . Al_2O_3	0·59	0·66
Ferric Oxide . . . . Fe_2O_3		
Lime	traces.	traces.
Water and non-siliceous organic matter. .	10·31	—

In Victoria the diatomaceous deposits are widespread, and in many cases of excellent quality. Near the Yarra are deposits of tertiary ages, estuarine in origin. They often contain calcareous material consisting of foraminifera and shells. As already stated, an unsuccessful attempt was made to manufacture fire-bricks by mixing this material with clay.

Extensive deposits are met with in the Mallee Scrub, near Swan Hill, on the Lower Murray River. Other important deposits occur at Lilicur, where they extend over four and a half acres and have a maximum thickness of $17\frac{1}{2}$ feet. Portions have been infiltrated with opal, which diminishes its value as in the case of the Wyrallah and Cooma deposits.

No diatomaceous deposits of importance have yet been reported from South Australia.

In Western Australia deposits of diatomaceous earth have been discovered on the northern shore of Lake Gnangarra, Wanneroo, Swan District, about eleven miles North of Perth. They are described by E. S. Simpson in the Annual Progress Report of the Geological Survey of Western Australia (Division IV. of the Reports of the Department of Mines) for 1902, p. 79. The visible supply is estimated at only 8,000 tons though it is probable that other deposits occur in localities where the conditions are similar.

The following are the results of the analysis of the material from Lake Gnangarra by the Geological Survey of Western Australia:—

		Material first supplied for analysis. *Partly calcined.*		Material carefully selected by the Survey.		
		Raw Material. Per cent.	*Ignited Material (calculated).* Per cent.	*Raw Material (wet) (calculated).* Per cent.	*Air-dried product.* Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	67·72	86·91	10·89	49·08	92·96
Alumina	Al_2O_3	9·98	12·81	0·78	3·51	6·65
Ferrous Oxide . .	FeO	trace	trace	trace	trace	trace
Magnesia. . . .	MgO	trace	trace	0·01	0·05	0·09
Lime	CaO	0·22	0·28	0·03	0·16	0·30
Water and non-siliceous organic material.	Lost on air-drying	—	—	77·88	—	—
	Lost at 100 C.	5·63	—	2·48	11·20	—
	Lost on ignition.	16·69	—	7·93	35·79	—
Bulk Specific Gravity . .				1·145	0·383	0·232
Relative change in weight .				100	22·1	12·2
Relative change in volume.				100	65·1	60·2

In June 1904 three samples of so-called "infusorial earths" were received at the Imperial Institute from Western Australia, which had been obtained either from Lake Gnangarra, or from a deposit formed under similar conditions. The first was stated to be in its natural state. It was a porous friable material of a pale brown colour. Under the microscope it was seen to consist mainly of minute siliceous fragments showing traces of organic structure.

This material on analysis in the Scientific and Technical Department of the Imperial Institute, gave the following results:—

		Material as received. Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2 soluble 41·39, insoluble 13·62	55·01	86·99
Alumina	Al_2O_3	4·80	7·59
Ferric Oxide	Fe_2O_3	1·45	2·29
Lime	CaO	1·00	1·58
Potash	K_2O	0·15	0·24
Soda	Na_2O	0·83	1·31
Non-siliceous organic matter		14·85	—
Combined water		14·35	—
Moisture		7·45	—

The second sample was whitish or cream-coloured. It was finer in structure, less friable than the first specimen, and slightly harder. It was said to be "vitrified," as the result of the application of intense heat, apparently without the addition of either lime or alkalis.

This material on analysis in the Scientific and Technical Department of the Imperial Institute, gave the following results:—

		Material as received. Per cent.	*Ignited Material (calculated).* Per cent.
Silica	SiO_2	86·00	86·75
Alumina	Al_2O_3	8·26	8·33
Ferric Oxide	Fe_2O_3	2·05	2·07
Lime	CaO	1·87	1·89
Potash	K_2O	0·16	0·16
Soda	Na_2O	0·80	0·81
Combined water and moisture		0·70	—

The third sample was described as calcined—in other words, heated sufficiently to burn out the non-siliceous material and expel most of the water, but not enough to cement the organic silica together.

The absorptive power of the calcined material is far greater than that of either the natural or the vitrified product. The non-conductivity to heat would be equally superior.

This material on analysis in the Scientific and Technical Department gave the following results :—

	Material as received. Per cent.	*Ignited Material (calculated).* Per cent.
Silica . . . . SiO_2	83·57	87·00
Alumina . . . . Al_2O_3	7·00	7·45
Ferric Oxide . . . . Fe_2O_3	1·67	1·78
Lime . . . . CaO	0·85	0·90
Potash . . . . K_2O	0·29	0·31
Soda . . . . Na_2O	0·52	0·55
Combined water	2·88	—
Moisture	3·38	—

In New Zealand deposits of diatomite are numerous, but little appears to be known up to the present of their commercial value (see W. Mantell, *Quart. Journ. Geol. Soc.*, Vol. vi., p. 332, (1850), and Card and Dun, *op. cit.*).

The best known locality is near Oamaru, between Christchurch and Dunedin, which appears to be a deposit similar to that in Barbados (H. A. de Lauteur, *Trans. N. Z. Inst.*, Vol. xxi. (1888), p. 293).

The total demand for diatomaceous earth in the United Kingdom is said to amount to about 3,000 tons per annum, part of which is obtained from Aberdeenshire and the remainder imported from Germany and Norway, most of it at prices varying from £3 to £4 a ton.

Although the demand is at present comparatively limited, there are so many directions in which the diatomaceous material are capable of being applied in the arts that a great increase in the consumption is by no means an improbable contingency.

One great obstacle to the export of colonial diatomite to Europe lies in the lightness of the material, which causes a high freight to be charged by shipowners. It is possible that

the difficulty may be overcome by shipping it on vessels carrying heavy goods, such as the metalliferous minerals which take up a comparatively small amount of space in proportion to their weight.

NOTICES OF RECENT LITERATURE.

NEW BOOKS.

LE COTON DANS L'AFRIQUE OCCIDENTALE FRANÇAISE. Par Yves Henry. Pp. 199. Bibliothèque D'Agriculture Coloniale Series. (Paris, Augustin Challamel, 1904.)

The author treats of the soil, climate, and present state of cotton cultivation in various parts of West Africa belonging to France, namely:—Senegambia, French Guinea, the Niger basin, and Dahomey. He discusses the question as to which regions are suitable and which are unsuitable to this cultivation, and then deals with the best methods of promoting the industry; treating first of its agricultural aspect, next of the machines suitable for ginning and baling, and lastly, of the commercial side of the question.

The two localities of immediate importance are the inland portions of Dahomey and the upper basin of the Niger. In Dahomey the natives are skilled agriculturists, and have grown cotton from very early times. A railway now runs from Kotonau on the coast, to Abomey in the interior, a distance of some 60 miles, and its extension northwards for 200 miles is projected. This line will afford great facilities for the export of cotton. The author makes the following estimate of the cost of placing a metric ton (1,000 kilograms, equivalent to 2,200 lb. English) on the Havre market. About 3,300 kilograms of seed cotton could be purchased from the natives at about 15 centimes a kilogram, and would cost 500 francs. This would yield one ton of cotton fibre at a cost of 60 francs for ginning and pressing. Transport by railway for 250 kilometres at 30 centimes per ton per kilometre would cost 75 francs; freight from Kotonau to Havre, 65

francs; various charges, 50 francs; making a total of 750 francs or 3·3*d.* per lb. From various parts of the Niger basin, with additional railway facilities, the price would not be very different.

COTTON MOVEMENT AND FLUCTUATION, 1899–1904. 31st Annual Edition. Pp. 176, with 6 plates. (New York, Latham, Alexander & Co., 1904.)

This work is a compilation of statistics relating to cotton, and includes tables of receipts, consumption, stocks, exports and fluctuations in the United States and in Europe, those relating to the American cotton trade being given in considerable detail. A special feature of the book is the inclusion of two articles, one written by Messrs. Ellison & Co. of Liverpool, and the other by Mr. Alfred B. Shepperson of New York. The former article reviews the cotton season of 1903–1904, which was recognised in the market as the most exciting and eventful for many years, and adds some remarks on the prospects of the 1904–1905 season. The latter article discusses certain statements which have appeared in the newspapers and elsewhere, alleging that the Southern States have deteriorated in their capacity for cotton production. The volume also contains an illustrated description of a new cotton-picking machine, and a portrait of the late Mr. Thos. Ellison of Liverpool.

THE SPINNING AND TWISTING OF LONG VEGETABLE FIBRES. By Herbert R. Carter. Pp. xvi.—360, with 161 illustrations (including 10 plates). (Chas. Griffin & Co., Limited, 1904.)

This book gives a practical account of the modern methods of preparing and spinning the long vegetable fibres of commerce, namely flax, hemp, jute, tow and ramie. A description is given of the various machines employed for hackling, carding, preparing, combing, drawing, spinning, and twisting these fibres, and an account of rope manufacture is added. The last four chapters are devoted to such subjects as the maintenance of machinery, mill construction, engines, motive power, and the methods of power transmission.

THE CULTURE OF TOBACCO. By G. M. Odlum, B.S., of the Department of Agriculture, Southern Rhodesia (pp. vi. + 185), with illustrations. (London. British South Africa Company, 1905.)

The author of this volume was commissioned by the Department of Agriculture in Southern Rhodesia to visit the principal tobacco-producing centres in the United States of America, with the object of studying the cultivation of tobacco as carried on there. The book now under notice is the result of the enquiry, and records the author's observations for the benefit of settlers in Rhodesia who already grow or who propose to grow tobacco.

The first portion of the volume deals with the various types of tobaccos and the modifications induced in these by altered external conditions, in particular by soil and climate. The method of cultivation is then taken up, the treatment of the soil, methods of harvesting and other similar subjects are dealt with, and finally thirteen pages are devoted to the discussion of the pests and diseases affecting the tobacco plant. The important subjects of "Curing" and "Fermenting" are next treated in detail, and the advantages and disadvantages of the various systems and their suitability for the production of particular types of tobacco are discussed. Finally the commercial aspect of the industry is dealt with, the various types of tobacco in demand in the principal producing countries, the requirements of the chief importing centres, the relative values of the principal markets and the costs of production are considered.

The book is provided with a number of coloured plates illustrating special types of tobacco, and with numerous reproductions of photographs of typical scenes in tobacco plantations in the United States, showing various characteristic features of the industry.

NOTICES SUR LES PLANTES UTILES OU INTÉRESSANTES DE LA FLORE DU CONGO. By Émile de Wildeman. Publications de l'État Indépendent du Congo, I., pp. 1–221 (1903), II., pp. 222–396 (1904.)

These volumes contain a series of some thirty independent

papers principally relating to economic plants of the Congo Free State. Summarised information is given of the properties and uses of plants occurring in the Congo, but not, in some cases, utilised at present. Thus under the heading *Les Eucalypts et leurs usages*, the species of *Eucalyptus* introduced into the Congo, and into German South-west and East Africa, are enumerated, followed by a general account of the various uses made of Eucalypts in different parts of the world. Other plants yielding useful products are similarly treated, and these summaries should prove of considerable service to those interested in the economic development of the Congo region, as indicating the latent possibilities of many of the plants, both native and introduced.

In addition, a mass of information is brought together on the local uses of indigenous plants. Several plants yielding dyes, drugs, oils, fodder, food stuffs, etc., are dealt with in considerable detail. Their botanical and native names are given in the majority of instances, with an account of the uses made of their products, and a *résumé* of investigations carried out upon them. Native methods of house building and the use of the leaves of one of the *Scitamineæ* as "roof tiles," are described and illustrated. Pictures of banana and coffee plantations, and cacao trees and drying sheds, serve as examples of local cultural methods. The bananas of Africa, including two new species, *Musa arnoldiana*, De Wild., and *M. gilletii*, De Wild., are described, accompanied by a number of plates. The timbers of the Congo are dealt with at considerable length, and separate lists, arranged according to the scientific and native names of the trees and the uses of the timbers, render the information given easy of reference.

A considerable number of other subjects are also dealt with, *e.g.* new orchids, a new cycad and acarophytes or "mite inhabited plants." In the course of the latter article Stapf's observation that the presence of *acarodomatia* enables *Funtumia elastica* to be distinguished from *F. africana* and *F. latifolia*, when only foliage is available, a point of considerable economic value, is noted.

LIME, MORTAR, AND CEMENT—THEIR CHARACTERISTICS AND ANALYSES, WITH AN ACCOUNT OF ARTIFICIAL STONE AND ASPHALT. By W. J. Dibdin, F.I.C., pp. xiv., 219. (London: The Sanitary Publishing Company, 1904.)

The author gives an account of the properties of the various products enumerated in the extended title of the volume quoted above. Descriptions of the tests—chemical and mechanical—usually applied to these products in order to ascertain their suitability for building purposes are given. The utility of these descriptions is increased by the insertion of a number of tables and diagrams giving in a readily comprehensible form the results of their application in typical cases. The book should be useful to those interested in the manufacture or use of cement and similar products.

COLONIAL PUBLICATIONS.

COPIES of the following publications, descriptive of the resources of the British Colonies, are now available for distribution at the Central Stand in the Exhibition Galleries of the Imperial Institute.

THE FOREST WEALTH OF CANADA. By James M. Macoun. A detailed account of the Canadian lumber trade is not attempted in this pamphlet, which is intended to draw attention to the vast timber resources of the Colony. A brief account of the condition of the timber industry in each of the Provinces is followed by a list of the principal commercial timbers of the Dominion, their distribution, relative abundance, and economic value being noted in each case. A table is added showing the nature of the forests in different parts of the country.

THE WOOD PULP OF CANADA. By George Johnson, F.S.S. This pamphlet deals with the growth and possibilities of the Canadian wood-pulp industry. The ever-increasing demand for

paper has caused manufacturers to seek for raw materials other than rags, straw, and esparto grass, and in wood pulp a suitable substitute for the production of certain varieties of paper seems to have been found. Pulp prepared from Canadian spruce (*Picea alba*) has proved to be of good quality.

The pamphlet contains an interesting history of paper-making, and is illustrated with photographs of Canadian waterfalls, which are, as in Norway and Sweden, the principal source of power for the wood-pulping machinery.

AGRICULTURE IN CANADA. By William Saunders, LL.D.

The first part of this book is concerned with a general account of Canada from the agriculturist's point of view. The variation of soil and climate in different parts of the Dominion are briefly discussed, and a short geographical account of the Provinces and Territories is given.

In the second part the chief agricultural industries of the different Provinces are described, information regarding transport, meteorological conditions, etc., being afforded in each case.

The author concludes with an account of the experimental work in agriculture now being carried out in Canada, and emphasises the importance of such work to the practical farmer.

HORTICULTURE IN CANADA. By William Saunders, LL.D. and Auguste Dupuis.

The authors give a short account of the chief fruit-growing districts of Canada, indicating the most suitable fruits for local cultivation. Attention is drawn to the experimental work in horticulture performed at Government farms, and to the encouragement and assistance afforded by the Government of the Colony to the fruit trade generally.

ECONOMIC MINERALS OF CANADA. By the Canadian Geological Survey Corps.

In this pamphlet the mineral resources of the different Canadian Provinces are described in some detail. The more important facts of the development of the mineral industry are

given, together with a discussion of present conditions and future prospects.

REVIEW OF IMPROVEMENTS IN THE LIGHTHOUSE AND COAST SERVICE OF CANADA, 1896–1903; also SUMMARY OF FISH BREEDING, FISH PACKING, AND SHIPMENTS OF FISH. Issued by the Order of the Minister of Marine and Fisheries, 1904.

The scope of this pamphlet is sufficiently indicated by its title. Part I. deals with such matters as the location of lighthouses and buoys, and the progress of the Tidal and Hydrographic Surveys. The Fisheries are considered in Part II.

Regulations for close seasons for fish, which came into force on 1st October, 1903, are given.

HANDBOOK TO BRITISH CENTRAL AFRICA. By Sir Harry Johnson, G.C.M.G., K.C.B.

This handbook is issued by the British Central Africa Co., as a guide to intending settlers, planters and miners, and sportsmen.

Malaria and its prevention are treated of at some length; the animal, vegetable, and mineral products of the colony are described; and information is supplied with regard to taxes, mining rights, customs duties, sporting licences, and regulations for the acquisition of land.

An appendix contains a list of the steamship lines serving Chinde, the port for the British Central Africa Protectorate, and information concerning these services is given. Many photographs, illustrating all phases of life in the country are supplied.

RAILWAYS IN RHODESIA. By E. H. Smith Wright. Issued by the British South Africa Co.

This volume, which is illustrated with photographs, aims at giving an account of the history and growth of railways in this part of British South Africa. The country served by the lines is fully described.

Mr. E. F. Knight's description of the Victoria Falls taken from *South Africa after the War* is incorporated. The prospects of farming and agriculture in Southern Rhodesia are discussed by Mr. E. Ross Townsend, Secretary for Agriculture in the Rhodesian Administration. Information concerning passenger services to South Africa is given.

TASMANIA, FROM AN IMMIGRATION POINT OF VIEW. By A. O. Green. Published by the Authority of the Government of Tasmania, 1903.

In this illustrated pamphlet the general features of the soil and climate of the colony are reviewed and summarised, and information is given regarding the "small industries" on which the agricultural prosperity of the island largely depends.

ITINERARY OF TRAVEL IN NEW ZEALAND, 1903–04. Issued by the Government Department of Tourist and Health Resorts.

This pamphlet contains illustrations of places of interest in the Colony, tables giving tourist routes, distances, fares, and similar information. For the benefit of sportsmen notes are added on the game seasons, deerstalking, protected game, and the fishing streams, with means of access and the nature of the accommodation available.

RECENT JOURNALS.

"BERICHTE UBER LAND- UND FORSTWIRTSCHAFT IN DEUTSCH-OSTAFRIKA."—This journal invariably contains a number of interesting articles dealing with the economic resources of German East Africa and their development, and the information thus published is frequently valuable to planters and others in the neighbouring territories. A recent number (Vol. ii., No. 3) includes notices upon a variety of different subjects, and a brief summary of the contents may be given here.

The cultivation of the Ceara rubber tree—*Manihot Glaziovii*—has received considerable attention in German East Africa during the last few years, and large plantations of the trees have already been formed. An article in the present "Berichte" gives a short account of the methods to be employed in raising the plants from seeds and establishing plantations of the trees, based upon experience gained in the district around Barikiwa and Liwale. It is stated that samples of ball rubber obtained from Ceara trees in this district were valued at 5·00 to 5·80 marks per kilogram in July 1902. It will be interesting to see what results are furnished by the Ceara trees in German East Africa, as they have given very variable and in some cases disappointing results when tried in other countries.

In another article a description is given of the methods employed by the natives of the Mataka tribe in the cultivation and preparation of tobacco, which is at present the only marketable product which these people raise. It is stated, however, that the possibility of inducing them to undertake the cultivation of the Ceara rubber tree in conjunction with tobacco is receiving consideration.

In connection with the forestry service of the Colony, one of the officials of this department furnishes a long account of the forests lying in the delta of the Rufiyi River. The character of the forests, their management, and the produce at present obtained from them are all fully dealt with. The principal timber trees present in this area are :—*Sonneratia caseolaris*, *Avicennia officinalis*, *Carapa moluccensis* and *obovata*, *Heritiera litoralis*, *Rhizophora mucronata*, *Ceriops Candolleana*, and *Brugiera gynnorrhiza*. The three latter belong to the mangrove class, and furnish barks containing tannin, which are largely used in Germany for the manufacture of leather.

Considerable attention has always been devoted in German East Africa to the study of the geology of the country, and in the present "Berichte" there are two articles upon this subject. One of these describes the geological and hydrographical features of the country lying between Kilwa on the coast and Songea, whilst the other is devoted to a study, from the agronomical standpoint, of the geology of the country round Amani.

THE EAST AFRICA QUARTERLY (published under the authority of the East Africa Agricultural and Horticultural Society, Nairobi, British East Africa).

The first volume of this publication, a quarterly journal devoted to the interests of planters in the British East Africa Protectorate and Uganda, has been recently received, and an inspection of its contents indicates that it is likely to be of considerable value to all those concerned in the economic development of these territories. The journal serves as a medium for the publication of official reports of interest to the planting community, and also contains numerous articles devoted to the various natural products, such as cotton, coffee, rubber, etc., which are suitable for cultivation in the country. A selection of articles from current literature is also given, together with much information upon topics of local interest.

Richard Clay & Sons, Limited, London and Bungay

BULLETIN

OF THE

IMPERIAL INSTITUTE

INDIAN AND COLONIAL COLLECTIONS.

THE COTTON EXHIBITION.

THE prospects of a serious deficiency in the supply of cotton to the mills of the United Kingdom, and of a greatly enhanced price for this raw material, which became apparent a few years ago, naturally directed attention to the capabilities of the British Colonies and Dependencies as fields for the cultivation of cotton; the subject thus became one of the most important of those problems with which the Imperial Institute deals, and was actively taken up.

A survey of the position and prospects of cotton cultivation within the Empire was undertaken by the Scientific Staff of the Imperial Institute, and was embodied in a Report by Professor Wyndham Dunstan to the Board of Trade in April, 1904 [Cd. 2020]. This survey showed the great importance to the British manufacturer of new sources of cotton supply, established over a wide area, and that there exists in British Territory an area suitable both as regards soil and climate, and also large enough to provide for the present requirements of the British cotton industry, and to keep pace with its natural increase for many years to come, provided that cotton of suitable quality can be grown. The importance to the future of cotton growing in such areas was demonstrated, of the guidance afforded both by the results of carefully-conducted and continuous scientific

experiments, and by the collection of information as to the progress made in foreign countries in cotton cultivation and as to the needs of manufacturers for special varieties of cotton.

In continuance of the work visits were paid by the Director and by members of the staff to several of the Colonies and Dependencies, and communication was established with the Governments of all those Colonies where this cultivation is possible. As a result, a large number of specimens of the different varieties of cotton now grown in these various localities were received, and, after having been examined in the Scientific and Technical Department, were submitted to commercial experts, and their market values were ascertained.

In order that the information thus obtained might be made available to the public, and that a wider interest might be aroused in the extension of cotton growing within the Empire, it was decided to make this collection of samples the nucleus for an exhibition illustrating British cotton cultivation and the commercial uses of cotton. The co-operation of the British Cotton Growing Association was obtained, and the exhibition is being held in conjunction with that body.

The exhibition is divided into four sections. The first of these deals with cultivation and experimental work, that is to say, with the cotton plant, the soils on which it grows, the pests that attack it, and with the qualities and peculiarities of the varieties that grow in the different Colonies and Dependencies and in Egypt. Over 200 samples of such cottons are shown, the character of their staples being brought out by a special method of mounting the fibres; they are also accompanied by particulars as to the length of their staple and their commercial value. Numerous samples of large bulk are displayed of the cottons of Rhodesia, British Central Africa, the West Indies, British Guiana, India and Egypt. By a comparison of these varieties, indications can be obtained of the direction which efforts at improvement should take. To afford further assistance in this a collection of the principal commercial cottons of the world has been similarly arranged, and there are also exhibited cottons from the Colonies of France, Germany and Portugal, lent by the Governments and Cotton Associations of those countries.

The second section deals with the present state of cotton production within the Empire. Actual commercial bales of cotton as exported from India, the West Indies, Lagos, Sierra Leone and the Sudan are shown, together with many smaller samples and photographs showing cotton cultivation in various British Colonies. The exhibits in this section have been collected by the British Cotton Growing Association.

The third section deals with the commercial preparation and uses of cotton. The first step, namely, the separation of the fibre from the seed by the process of ginning, is shown by both hand and power gins in operation; the packing of the separated fibre in bales adapted for transport is shown by baling presses and by diagrams. The treatment the cotton passes through after its arrival in this country, as it is spun into yarn and woven into cloth, is shown by a series of diagrams of the machines employed, each accompanied by specimens of the products they yield. Each stage of the manufacture is thus illustrated. Cases containing cloths of various kinds lent by leading firms of manufacturers are exhibited, showing how numerous and varied are the fabrics which can be made from cotton alone; cases are also shown of the products obtained by combining cotton with wool.

The utilisation of the secondary and waste products of cotton and cotton seed is shown by cotton waste and its products, and by specimens illustrating the steps in the manufacture of oil and of feeding cake for cattle from cotton seed.

The fourth section comprises machinery used in the preparation, manufacture and testing of cotton; gins and baling presses are shown as being of great interest to Colonial visitors, since these operations have to be performed before shipment, and the establishment of inland ginning stations greatly facilitates the transport of cotton to the coast. Model looms are exhibited, and a large power loom of the Jacquard type is shown in operation, weaving towelling with a lettered design. An interesting series of models illustrating the great inventions of the eighteenth century in the domain of cotton manufacture has been lent by the Board of Education from the collections of the Victoria and Albert Museum.

A handbook of the exhibition has been compiled, which, besides being a catalogue of the objects exhibited, gives a

general account of cotton growing, together with descriptions of the conditions of the industry in each of the different British and foreign countries concerned in it, embodying the special descriptions of the samples shown. In it the operations in the different stages of cotton manufacture are explained, as well as the nature of the various fabrics exhibited.

The exhibition was opened on the first of June, when it was visited by H.R.H. the Prince of Wales.

RECENT CHANGES IN, AND ADDITIONS TO, THE PERMANENT COLLECTIONS.

CONSIDERABLE progress has been made in the reorganisation of the collections on the lines of the general scheme, outlined in the *Bulletin of the Imperial Institute*, Vol. ii., p. 139.

The exhibits of Cape Colony, Jamaica, West Australia, Victoria, South Australia, New South Wales and Ceylon products have been entirely rearranged and placed in definite groups, vegetable products, for instance, being classed according to their uses.

MAPS ADDED TO THE COLLECTIONS.

The following new maps have been framed and placed in the collections:—

West Indies.—General map showing the whole of the West India Islands and the coast of North and South America from Carolina to British Guiana; Tobago, Trinidad and the adjacent mainland; Tobago; the chain of islands from Guadeloupe to Trinidad; Grenada; St. Vincent; St. Lucia; Barbados; Dominica; Antigua; Montserrat; St. Kitts, Nevis, St. Eustatius and Saba; Bahamas.

Equatorial Africa.—Sierra Leone; Sierra Leone Railway and proposed extension to the Liberian frontier; Gold Coast—Sekondi to Kumasi Railway; Lagos to Ibadan Railway; Uganda—Mombasa to Victoria Railway; British Central Africa, showing the different rainfall areas.

Australia. — South Australia — geological map of the Northern Territory of the State; Australian States, showing approximate route of the proposed Transcontinental Railway; Tasmania, topographical and geological maps.

EXHIBITS ADDED.

CAPE COLONY.

Wool and Mohair.—A set of samples of wool and mohair has been placed in the Cape Colony Court, comprising samples from the following exhibits, all of which won first prizes in their classes at the Port Elizabeth Agricultural Show, 1904 :—

(1) Best 500 lb. Hoggett's Grease Wool. Mixed Veldt.
(2) Best 1,000 lb. Grease Wool (Sheep—11 months old).
(3) Best 1,000 lb. Grease Wool. Grass Veldt.
(4) Best 3,000 lb. Grease Wool. Mixed Veldt.
(5) Best entire 20 Fleeces. Merino Wool (11 months old).
(6) Best 500 lb. Lambs' Wool (6 months).
(7) Best 500 lb. Mohair. Grown in the Karroo.
(8) Best 500 lb. Mohair. Grass Veldt.
(9) Best 100 Fleeces Mohair. Grass Veldt.
(10) Best 100 Fleeces Mohair. Grown in the Karroo.
(11) Best 250 lb. Kids' Hair. Grown in the Karroo.
(12) Best 250 lb. Kids' Hair. Grass Veldt.

STRAITS SETTLEMENTS AND FEDERATED MALAY STATES.

Rubber.—The collection of rubber specimens previously in this Court has been increased by the addition of samples of "biscuit" Para rubber, some self-coagulated and others prepared by the acetic acid method, also of specimens of the seed of the Para rubber tree (*Hevea brasiliensis*), and the oil prepared from these seeds (see *Imperial Institute Bulletin*, Vol. i., p. 156, and Vol. ii., p. 22). The general features of a rubber estate, and the habit of growth of Para and Rambong or Assam rubber trees (*Ficus elastica*) are well illustrated by a set of four photographs taken in January, 1904, on an estate in Klang, Selangor, Federated Malay States. Recently-cleared land planted with *Ficus elastica* and mixed rubber and coffee plantations is also shown. One view illustrates incidentally the method of partial ringing practised on the shade trees (*Pithecolobium Saman*) to prevent excessive growth.

Rice.—The rice plant (*Oryza sativa*) is extensively cultivated in the Straits Settlements and Federated Malay States, but not

at present in sufficient quantity to meet the local demand. The plant may be grown on the plains in fields artificially flooded with water, or on hillsides, without irrigation, just as any ordinary crop. Different varieties of *Oryza sativa* are adapted to these very different conditions, those which grow on the plains being known as "wet padi," and those which grow on the hills without irrigation as "dry padi" or "hill padi." A large number of specimens of the grains of these varieties have for some time been in the Court, and recently the value of the exhibit has been enhanced by the addition of specimens of both "wet padi" and "hill" or "dry padi" as borne on the plants, or, if the expression may be used, "in the ear." In addition to the ordinary rice plant (*O. sativa*) there is cultivated another species (*O. glutinosa*), locally known as "pulut." It differs from rice in that the grains are more translucent, and when cooked are glutinous and sweet; on this account it is sometimes called "sweet rice." Pulut is used in Malaya for puddings, etc., and there would appear to be a possible market for it as an article of export. A specimen of "pulut" in the ear has recently been added to the Court, where a large number of the varieties of this grain are also exhibited.

Marble.—Marble occurs in many places in the Federated Malay States, and large works have been erected in Kinta, Perak, to quarry, cut and polish the stone. A series of nine large slabs of marble, cut and polished at the Kinta works, have recently been received from the Director of the Taiping Museum, Perak, and added to the Court.

Silk Textiles.—The Director of the Perak Museum has also forwarded three silk "sarongs" made at Pekan, Pahang, Federated Malay States.

WESTERN AUSTRALIA.

The Agent-General for the State has added to the Court a section of the Mephan Ferguson locking bar, rivetless pipe and joint ring. The pipe is 30 inches in diameter and made of ¼ inch steel-plate. The Western Australian Government adopted this form of pipe for the Coolgardie Water Scheme, and 360 miles of it were laid down.

NEW SOUTH WALES.

TIMBERS.

IN proportion to its area, New South Wales is one of the most richly endowed countries in the world as regards forest wealth. In spite of the large clearings which have been made by settlers, there are still large areas of practically virgin forest in the coastal and mountain regions, and in many of the partially cleared forests young trees are coming forward, and appear to be flourishing. The stability of the timber supply would thus appear to be fairly well assured, but there is urgent necessity for, at least, the conservation of the forest, since in New South Wales, as in many other timber-producing countries, there is a strong tendency to live upon the capital wealth without regard to the future. Conservation is of especial importance to New South Wales, where the demand for timber is confined to comparatively few species, the incessant cutting of which must inevitably lead to the serious depletion of supplies.

Within recent years the forest flora of the colony has received considerable attention from both the scientific and economic standpoints. The most important publications have been Baker and Smith's *Research on the Eucalypts, especially in regard to their Essential Oils*, and Maiden's *Forest Flora of New South Wales*, *A Critical Revision of the Genus Eucalyptus* and *Notes on the Commercial Timbers of New South Wales.* The purely scientific work will no doubt prove of the greatest value to practical men, both in New South Wales and in England, in enabling them to cope with one of the greatest difficulties met with in dealing with timbers from new, or comparatively new, countries, viz., correct identification.

The extensive collection of timbers in the New South Wales Court of the Imperial Institute has recently been carefully compared with the lists given in the second edition of Maiden's *Notes on the Commercial Timbers of New South Wales* (Sydney, 1904). The Court contains specimens of the great majority of the woods described in the pamphlet, and, in addition, examples of some thirty-six timbers which do not appear to be used commercially, but which, if better known, would probably be found useful for many purposes.

In the following notes the more important timbers exhibited in the Court are grouped according to their suitability for special purposes. The descriptive information is derived from the pamphlet referred to above.

A special map illustrating the distribution of the principal trees of the State is displayed above the case of timber exhibits.

1. *Paving Timbers.*

Tallow-wood (*Eucalyptus microcorys*, F. v. M.). Probably the most valuable of New South Wales woods for road-paving. It is strong, heavy and durable, and, on account of its greasy character, is particularly suitable for the flooring of ball-rooms. It does not burn readily, and is largely employed for general building work. The tree is not abundant, but occurs in the coast districts and Dividing Range from Newcastle northwards.

Blackbutt (*Eucalyptus pilularis*, Sm.). This timber has been tried for many years for wood-paving with very satisfactory results; it takes tar well and is very durable. It is useful for bridge-planking and ship-building. The tree occurs plentifully in the coast and mountain districts from north to south.

Red Mahogany (*Eucalyptus resinifera*, Sm.). A hard, durable timber of a rich red colour, very suitable for wood paving, and said to be often substituted, with perfect success, for Jarrah (*E. marginata*, Don.). The supplies are fairly plentiful, and occur in the northern coast districts.

Forest Red Gum (*Eucalyptus tereticornis*, Sm.). A hard, durable and heavy timber of a deep-red colour. It is apt to warp in seasoning, but is recommended by Maiden as a useful wood for paving purposes. There are abundant supplies in the coast and mountain districts, and also in the tablelands.

Bloodwood (*Eucalyptus corymbosa*, Sm.). This is one of the most durable of Australian timbers. The presence of gum-veins militates against its extensive adoption as a paving material, but, on the other hand, a moderate amount of gum is said to preserve the wood and in no way need hinder its use as wood pavement. There are fairly plentiful supplies of the timber in the coast districts and in the Blue Mountains.

Brush Box (*Tristania conferta*, R. Br.). A tough, strong and durable timber, largely used for trolley rails in the forests of the

northern districts. If felled at the right time of the year and properly seasoned, it would form a useful wood for paving blocks. Large quantities are available from Port Stephens to the Tweed.

A special exhibit of New South Wales paving blocks is arranged in the Upper Central Gallery. It includes blocks from six species of Eucalyptus, viz., Red Gum, Spotted Gum, Blue Gum, Blackbutt, Tallow-wood and Red Mahogany, and from Turpentine and Brush Box. Several of the blocks have been in use on the roads of Sydney for periods varying from three to twelve years, and serve to indicate the durability of the timbers employed. In connection with this point it may be mentioned that a small portion of Pall Mall (between Haymarket and Waterloo Place) was paved in 1903 with blocks of Brush Box, Tallow-wood and Blackbutt from New South Wales, with a view to testing their value in comparison with other paving blocks at present used in London.

2. *Timbers suitable for Railway Wagons and Sleepers.*

Ironbarks. New South Wales possesses four useful ironbarks (species of Eucalyptus), the two most important being exhibited in the Court. A less valuable variety is also shown. These timbers are extensively used in bridge construction, for railway sleepers and wagons, and for any purpose where great strength is required. The Court contains four ironbark sleepers taken up after thirty-five years' service on the Main Southern line. Their sound condition indicates the suitability of the timber for such purposes.

(*a*) White or Grey Ironbark (*Eucalyptus paniculata*, Sm.). The best white ironbark is very pale in colour, and is the hardest of all the timbers of this class. Specimens from the Moruya district have a medium red colour. The tree is common in the coast districts and mountain ranges from north to south.

(*b*) Narrow-leaved Ironbark (*Eucalyptus crebra*, F. v. M.). A deep-red timber of great value, but inferior to the best qualities of white ironbark. It is widely diffused in the State, but occurs principally on the eastern side of the Dividing Range.

(*c*) Red Ironbark (*Eucalyptus sideroxylon*, A. Cunn.). The least valuable of the ironbarks, but a useful timber where great

lengths are not required. It is dark-red in colour, and found chiefly in the gold-bearing districts of the interior.

Grey Gums (*Eucalyptus punctata*, D.C., and *E. propinqua*, D. and M.). Very similar in appearance to red ironbark, but of somewhat inferior strength. It is, however, largely used for sleepers with satisfactory results. There are plentiful supplies of the timber in the northern coast districts.

Blackbutt (*Eucalyptus pilularis*, Sm.).

Brush Box (*Tristania conferta*, R. Br.).

3. *Timbers for Carriage Building.*

Coachwood (*Ceratopetalum apetalum*, D. Don.). Asserted to be one of the most valuable timbers in the State for coach-building. It works freely and has little tendency to split in seasoning.

Red Cedar (*Cedrela australis*, F. v. M.). A valuable timber resembling mahogany in appearance, but possessing only half its weight. It is easily worked and very durable. This timber has been largely used for furniture and joinery for nearly a century, and the present supplies found between the Richmond River and the Tweed are somewhat limited.

White Beech (*Gmelina Leichhardtii*, F. v. M.). A pale-coloured timber of somewhat close grain, and drying with very little shrinkage. It is used for general carpentry purposes, and is said to be valuable for wine casks. The tree is found in the coast districts from the Shoalhaven northwards, but is not abundant.

Bolly Gum (*Litsea reticulata*, Benth.). This tree yields a soft whitish timber, suitable for coach-building and many other purposes. It is found from the Hawkesbury River northwards.

Blackwood (*Acacia melanoxylon*, R. Br.). A valuable and well-known timber, suitable for furniture and carriage-building. The trees, however, are generally found so distant from markets as practically to preclude its export. Supplies are readily obtainable in Tasmania and Victoria.

Mountain Hickory (*Acacia penninervis*, Sieb.). A timber closely resembling blackwood in appearance and properties. It is abundant in many parts of the southern districts.

4. *Timbers for Cabinet Making.*

Red Bean (*Dysoxylon Muelleri*, Benth.). A handsome red timber, which has been used as a substitute for Spanish mahogany. The trees are found in the valleys of the northern rivers, but the supplies are not large.

Black Bean (*Castanospermum australe*, A. Cunn.). A timber strongly resembling dark, fine-grained walnut. It shrinks somewhat in drying, and is of a greasy nature. Fairly abundant supplies are found between the Clarence and the Tweed. The suitability of this wood for indoor work is illustrated by a doorway exhibited in the Upper Central Gallery.

Red Cedar.

Blackwood.

5. *Timbers for Veneers.*

She-Oak (several species of *Casuarina*). A hard, heavy and frequently tough timber, with a handsome, oak-like grain. Most of the native species are very fissile. Large supplies are available in many parts of the State.

Red Silky-Oak, Beefwood (*Stenocarpus salignus*, R. Br.). A reddish fissile timber, used locally for a variety of purposes.

Honeysuckle (*Banksia integrifolia*, L.: distinguish from New Zealand Honeysuckle, *Knightia excelsa*, R. Br.). A wood chiefly used for boat-building and bullock yokes. It is pinkish in colour and possesses a good grain. Boat-knees of this wood are exhibited in the Court.

Black Bean.

6. *Timbers for Staves.*

Silky-Oaks (*Grevillea robusta*, A. Cunn., and *Orites excelsa*, R. Br.). These trees yield light-coloured timbers with a handsome, silky figure. The wood splits readily, and has been largely used as staves for wine, butter and tallow casks. *G. robusta* occurs in the bush forests from the Little River northwards. *O. excelsa* is found on the tablelands north of Mount Royal in the Singleton district.

Red Silky-Oak.

Mountain Hickory.

Blackwood.

Coachwood.

7. *Timbers for Gunstocks.*

A series of eleven gunstocks made from New South Wales woods is shown in the Court. The woods used are Myall (*Acacia*, spp.), Red Bean, Black Bean, Hickory, Honeysuckle and Sycamore.

8. *Timbers for Turnery.*

Several specimens of turnery are shown, table-legs of Silky-Oak, Red Gum, Bastard Myall (*Acacia Cunninghamii*, Hook.) being the best examples.

9. *Timbers for Panels, Picture Frames and Walking Sticks.*

The suitability of certain timbers for these purposes is illustrated by examples.

10. *White Ant-resisting Timbers.*

Cypress Pine (several species of *Callitris*). This timber is largely employed for all purposes where ant-resisting qualities are a necessity. There are a few drawbacks to its use, however, the chief being its brittleness and inflammability. Large quantities are available in the drier parts of the country.

Native Teak (*Flindersia Bennettiana*, F. v. M.). A large tree yielding a durable and heavy timber, which is hard and difficult to work. It is very inflammable when green, but far less so when properly dried. It is found chiefly in the bush forests of Richmond and Tweed valleys.

Red Mahogany.
Brush Box.
Red Cedar.
Turpentine.

11. *Teredo-resisting Timbers.*

Turpentine.
Tallow-wood.
Red Mahogany.
Ironbarks.

CEYLON.

Thorianite.—A specimen of thorianite from the Central Province, Ceylon. This new mineral is referred to on page 155. It contains nearly 80 per cent. of uncombined thoria, and is in demand for the manufacture of incandescent gas mantles.

Plumbago.—A set of ten photographs, from negatives taken by G. Stonier, Esq., F.G.S., who kindly lent them for the purpose, have been added. They represent the head of a graphite mine shaft, and the various processes of screening and polishing on sieves and on sacking, washing, sun-drying and flying or "vanning" the dust.

PEARLS.

Although Ceylon is essentially an agricultural country, and animal industries at the present time do not claim a large share of attention, there are several marine industries of sufficient importance to warrant special notice. The chief of these are the famous Pearl Fishery off the north-west coast of the Island, and the fisheries for Chanks and Bêche-de-mer; the once important Tampalakam pearl industry is now extinct, owing to the almost complete exhaustion of supplies.

The above industries are all represented by specimens in the Ceylon Court of the Imperial Institute. The exhibit of Tampalakam oysters is of interest, since the question of the possible revival of this fishery is to receive the attention of the Government Biologist. The Bêche-de-mer industry is represented by specimens of the animal preserved in spirit, and by examples of the dried and cured product as placed on the Chinese market. Numerous specimens of chanks are exhibited, the different grades and qualities being well represented; the instrument used for grading the shells is also shown. The Pearl Fishery is illustrated by specimens of the pearl oyster in three stages of growth, including the adult animal in which the pearls are found.

The Pearl Fishery has long been an important source of revenue to the successive governments of Ceylon, and in the interests of the industry a complete investigation of the pearl-banks, from both the practical and biological standpoints, has

recently been carried out by Professor Herdman, F.R.S., of Liverpool. The following notes on the industry have been compiled chiefly from the Report on the investigation now being published by the Royal Society at the request of the Colonial Government.

The pearl fisheries of Ceylon, yielding with the fisheries of India and the Persian Gulf the highly-prized "Oriental Pearl," are of very great antiquity. Probably the earliest reference to Ceylon pearls occurs in the Sinhalese national record, the Mahawanso, in which they figure in a list of royal presents sent to India by King Vijàya about 550 B.C. The Phœnicians visited the Island regularly for its gems and pearls, and were succeeded by the Romans and Levantine Greeks. Later the trade of the East passed into the hands of the Arabs, who were supreme until the beginning of the sixteenth century; frequent reference is made in their writings to the pearls of Ceylon. European control of the fishery was not obtained until after Vasco de Gama discovered the new route to the Indies, when the Portuguese ousted the Arabs from their commercial position. The Portuguese were, in their turn, succeeded by the Dutch, who, although having a series of successful fisheries, found the industry unprofitable owing to the frequent occurrence of unproductive years. The last Dutch fishery took place in 1768, and in 1796 the industry passed into the hands of the British Government.

The pearl banks of Ceylon are situated towards the head of the Gulf of Manaar, off the north-west coast of the Island, and consist of a northern and southern division. The former is the more important, extending over an area nearly twenty miles square, while the latter forms a long line of banks stretching from Kudiramali in the north to Negombo in the south. The banks, or "paars" as they are termed, occur at depths of from six to nine fathoms, and cover discontinuously an extensive submarine plateau which on its seaward face forms a precipitous cliff, falling away to several hundred fathoms. The best known and most productive paars lie at some distance out to sea, the Cheval Paar, the Periya Paar Kerrai and the Modragama being respectively about eleven, twelve and fifteen miles from the nearest coast. The banks are patches of hard ground formed in

some instances of corals and shells, but in the majority of cases by a "calcrete" of sand and organic remains at the present time undergoing a process of consolidation into rock by the deposition of calcium carbonate.

Upon these paars the pearl oyster (*Margaritifera vulgaris*, Schumacher) in favourable years occurs abundantly. The animal is not, strictly speaking, a true oyster, but is more nearly allied to the mussels, with which it agrees in possessing a "byssus" or strand of tough threads by which it attaches itself to the rocky substratum. A loose sandy sea-bottom is more or less useless for the formation of a pearl bank, since, among other reasons, it affords no immovable objects for the attachment of the byssus.

The fishery is under the control of a Government officer, who examines the beds twice a year and estimates the number of oysters present in each bank. If the oysters are of a satisfactory size and in sufficient abundance, a sample of about twenty thousand is collected by native divers, and a valuation made of the pearls yielded by them. A return of from ten to twelve rupees per thousand oysters is held sufficient to warrant a fishery, and in such a case a fishery is proclaimed by Government, and divers and merchants invited to attend from all parts of India and Ceylon. At the same time details are published concerning the valuation of the sample pearls, the area to be fished, and the number of oysters estimated to be available.

The organisation of the fishery, which takes place during the calm period of the north-west monsoon, is in the hands of the Government Agent of the Northern Province. This officer selects a suitable site for the camp, and arranges for the temporary erection of the necessary dwelling huts, hospitals, police barracks and other buildings, and also sheds for the storage of the oysters obtained. The prospects of a good fishery will attract as many as 30,000 people to the camp.

The fishing fleet is divided into two sections, operating on alternate days. The divers descend upon a heavy stone attached to a rope, and carry down with them a basket attached to a second rope. They remain under water for from 40 to 85 seconds, according to individual powers of endurance, and collect into the basket as many oysters as possible. The

divers receive one-third of the oysters fished as wages. The remaining two-thirds is Government property, and is put up to auction in lots of 1,000. The average price obtained is about £2 per lot, but returns as low as 15*s.* 8*d.* are recorded; on the other hand, the record price of £12 17*s.* 10*d.* per thousand was obtained in 1860.

The pearls are extracted from the oyster by the primitive and offensive method of allowing the contents of the shells to putrefy and decay, the process being greatly facilitated by the presence of multitudes of fly-maggots. When the putrefaction is complete the mass is repeatedly washed, until a residue of solid particles is obtained. The residue, which contains the pearls, is then dried and carefully picked over many times.

The pearls are graded according to size, lustre and shape. In sizing the pearls a series of bowl-shaped sieves is employed, but the assessment of the lustre admits of considerable diversity of opinion among the valuers.

A marked feature of the Ceylon Pearl Fishery, under all administrations, has been its uncertainty, long intervals elapsing during which it has been unprofitable to fish the oysters. During the Dutch occupation there were several such periods, notably those between 1732–1746 and 1768–1796. Later records show that under British rule several similar failures have occurred, the longest being from 1820 to 1828, from 1837 to 1854, and from 1864 to 1873.

The intermittent character of the fishery has long been a matter of concern to the Government, and from time to time investigations have been made in the hope of placing the industry upon a more permanent basis, but up to the beginning of the present century few practical conclusions had been arrived at. In 1902, however, Professor Herdman, F.R.S., at the invitation of the Government, initiated a series of exhaustive investigations upon the nature and condition of the pearl banks, the life-history of the oyster, and the numerous biological problems which have proved to be so intimately connected with the distribution of the animal and the formation of the pearls themselves. As a result of the investigation it has been possible to put forward many suggestions and recommendations, which, it is hoped, may prove of considerable value to the industry.

Not the least important outcome of the inquiry is the establishment of a Marine Biological Station at Galle in charge of a biologist, who will carry out the suggestions embodied in the Report, and investigate further problems, not only those in connection with the pearl industry, but also others concerned with the extension of existing small marine industries, such as the chank and trepang fisheries, and the establishment of possible new ones, *e.g.*, a sponge fishery.

The purely scientific part of the investigation has resulted in discoveries of great economic importance. It was shown that, in the great majority of cases, "Orient" pearls are formed by the deposition of nacre around the *dead* bodies of the spherical larvæ of a small marine tape-worm (*Tetrarhynchus*) which infects the Ceylon pearl oyster, and not, as is so generally supposed, around an intruding sand-grain. In the case of the less valuable "seed" pearls, the irritant body is a small crystal found in certain muscles of the animal, and around which the nacre is similarly deposited. The life-history of the tape-worm causing the formation of Orient pearls was carefully worked out. The parasite was traced from the oyster to certain species of file fishes (*Balistes*), which prey upon shellfish, and thence to the large fish-eating rays or sharks which, in their turn, feed upon the file fishes. In the rays the worm becomes mature, and sets free into the sea numerous embryos, which finally enter the body of the oyster and begin a new cycle of life-phases. The presence of the different hosts is, of course, essential for the completion of the life-history of the parasite, and as a result of the investigation it now becomes feasible to influence artificially the production of the finer pearls whenever the oyster can be cultivated in land-locked areas in which infected ray fishes can be kept alive in cage enclosures.

The practical conclusions arrived at by Professor Herdman may be briefly summarised as follows:—

(1) The Cheval and North and South Modragam Paars, together with the Periya Paar Kerrai and the Muttuvaratu Paar still form valuable and reliable fishing grounds. Others, *e.g.*, the Chilaw, Dutch Modragam, Alantura and Karativu, are less reliable, but may prove valuable on occasions.

(2) The Periya Paar and others cannot be relied upon to

produce adult stock suitable for fishing, but might be used as sources of supply of young brood oysters.

(3) A number of the smaller paars are practically useless from an economic point of view.

(4) The most important agent in causing widespread destruction of pearl oysters in the Gulf of Manaar is the covering of the paars with sand drifted by the strong currents and the south-west monsoon. Next in importance are the ravages of natural enemies, the chief of which are (*a*) voracious fishes, chiefly rays and file fishes; (*b*) boring mollusca, worms and sponges; (*c*) starfishes. With regard to the fishes mentioned under (*a*) it must be remembered that their presence is essential to the formation of pearls in the oysters, and that the loss of a certain number of the latter is a toll which should be willingly paid.

(5) Overcrowding, disease and overfishing may, on occasion, prove disastrous.

(6) It is desirable and practicable that spat should be transplanted from unfavourable to favourable ground, and that overcrowded beds should be thinned out.

(7) The banks should be carefully inspected and speedy fisheries undertaken at the right time.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since the 27th February, 1905.

The Cotton Growing Problem in Sierra Leone . . . . . By H. H. Lardner.
(*The Author.*)

The World's Commercial Products, with French, German, and Spanish Equivalents for the names of the commercial products . . . By J. A. Slater, B.A., LL.B.
(*Sir Isaac Pitman & Sons, Ltd.*)

Hakluyt's English Voyages . .	Edited by E. E. Speight, B.A., F.R.G.S. (*Messrs. Horace Marshall & Son.*)
Journal of the Royal Agricultural Society of England. Vol. lxv. .	(*The Secretary.*)
Natal Almanac and Directory for 1905	(*Messrs. P. Davis & Son.*)
The Fauna of British India, including Ceylon and Burma. Butterflies. Vol. i.	By Lieut.-Colonel C. T. Bingham. (*Under Secretary of State for India.*)
The Manuring of Cotton . . .	By G. Foaden. (*Khedivial Agricultural Society.*)
Sun Pictures of the Antilles and British Guiana	By E. A. Aspinall. (*The Author.*)
Walch's Tasmanian Almanac, 1905 .	(*Agent-General for Tasmania.*)
The Canadian Almanac for 1905 .	(*The Copp Clark Company, Ltd.*)
Proceedings of the Royal Institution of Great Britain. Vol. xvii. Part 2. No. 97, March, 1905 . .	(*The Secretary.*)
The Stock Exchange Official Intelligence, 1905	(*The Secretary.*)
Directory and Chronicle for China, Japan, Straits Settlements, Indo-China, Philippine Islands, etc., 1905	(*The Hong Kong Daily Press.*)
Directory of Paper Makers for 1905	(*The Editor, Paper Makers' Journal.*)
Le Liège: ses produits et ses sous-produits	By M. Martignat.

L'Industrie Oléicole: fabrication de l'huile d'olive	By J. Dugast. (*Messrs. Gauthiers-Villars.*)
Speeches of the Right Honourable Harry Escombe, LL.D. . . .	Edited by J. T. Henderson. (*The Editor.*)
Sand's Sydney Directory for 1905 .	(*Messrs. Gordon & Gotch.*)
National Physical Laboratory: Report for 1904	(*The Director.*)
Schlich's Manual of Forestry. Vol. iii.—Forest Management. Third edition, revised	By W. Schlich, C.I.E., Ph.D. (*The Author.*)
Historica Técnica del Puerto de Buenos Aires	By Luis A. Huergo. (*Messrs. Torromé, Sons & Co.*)
The Coal Fields of Great Britain: their History, Structure, and Resources, with Descriptions of the Coal Fields of our Indian and Colonial Empire and of other parts of the World . . .	By Edward Hull, M.A., LL.D., F.R.S. (*Messrs. Hugh Rees, Ltd.*)
Selections from Prescott's History of the Conquest of Mexico . .	Edited by A. S. Lamprey, B.A.
Selections from Prescott's History of the Conquest of Peru . . .	Edited by A. S. Lamprey, B.A. (*Messrs. Horace Marshall & Son.*)

The Microscopical Examination of Sumach Adulterants. Reprinted from the *Journal of the Society of Chemical Industry, Yorkshire Section.* March, 1905 . . .	By Howard Priestman. (*The Author.*)
Tea Cultivation in Ceylon. Pruning and Kindred Subjects . . .	By "Rustic" (Edward Hamlin). (*Messrs. A. M. & J. Ferguson.*)
Livingstone College Year-Book for 1905	(*The Secretary.*)
Records of the Cape Colony. January to September 1826	By George McCall Theal, D.Lit., LL.D. (*The Colonial Secretary.*)
Annales de l'Institut Colonial de Marseille, 1903 and 1904 . .	(*The Director.*)

SCIENTIFIC AND TECHNICAL DEPARTMENT.

I.—REPORTS ON RECENT INVESTIGATIONS.

The following accounts of investigations have been summarised from a selection of the Reports recently furnished to the Indian and Colonial Governments.

ROCKS AND MINERALS FROM THE BRITISH CENTRAL AFRICA PROTECTORATE.

THIS consignment of rocks and minerals, including some gem stones, was forwarded by the Deputy Commissioner for British Central Africa, in order that the specimens might be chemically examined or identified. Reports on the examination of

previous consignments of minerals from British Central Africa have already been published in the *Bulletin of the Imperial Institute*, 1904, Vol. ii., pp. 69 and 73.

Subsequently the Commissioner for British Central Africa forwarded a second sample of galena, found 25 miles distant from the locality in Angoniland, from which the specimen marked D, included in the first consignment, was obtained, and it was especially desired to ascertain whether this second sample contained a larger proportion of silver than the one already sent.

These specimens have been examined in the Scientific and Technical Department of the Imperial Institute, and have given the following results:—

Specimen A, collected in the West Nyasa District.—This specimen consisted of angular quartz grains cemented together by ferruginous material. It was assayed for gold and this metal proved to be absent.

Specimen B, from the Blantyre District.—This material was a quartz-oligoclase-felspar rock containing copper pyrites with bornite and malachite. The portion of the mineral soluble in acids was analysed and gave the following results:—

	Per cent.
Alumina (Al_2O_3)	2·39
Iron (Fe, other than sulphate)	5·70
Ferrous sulphate ($FeSO_4$)	0·24
(Total iron = 5·78)	
Cobalt (Co)	trace
Copper (Cu)	5·31
Lime (CaO)	1·15
Magnesia (MgO)	0·18
Sulphur (S)	4·92
(Total sulphur, including that present as ferrous sulphate = 4·97)	
Combined water (H_2O) / Moisture	1·27
Residue insoluble in acids	78·70

The copper occurs principally as sulphide, the iron as sulphide and sulphate. No gold was found, but for a satisfactory gold assay a larger sample should be examined.

This ore would have to be concentrated by mechanical means before it would be rich enough for smelting as a copper ore. This concentration could only be carried out economically if there were abundant water supply and power, from water or fuel, available on the spot.

Specimen C, collected in the Blantyre District.—This mineral was a nickeliferous pyrrhotite, containing copper pyrites, biotite mica and possibly pentlandite and polydymite.

An analysis gave the following results :—

		Per cent.
Iron	Fe (present as sulphide)	41·28
Ferrous oxide		2·52
	Total iron, 43·26	
Cobalt	Co	0·279
Nickel	Ni	3·96
Lead	Pb	0·28
Copper	Cu	0·992
Manganous oxide	MnO	0·43
Lime	CaO	1·72
Magnesia	MgO	2·07
Alumina	Al_2O_3	3·63
Sulphur	S	30·23
Sulphuric acid	SO_3	0·79
	Total sulphur, 30·55	
Arsenic	As	nil
Silica	SiO_2	10·33
Combined water (in the insoluble residue)		0·70
Moisture		0·43

There appeared to be a trace of platinum present in this specimen, but it will be necessary to examine a larger sample before the presence of this precious metal can be definitely asserted.

This ore closely resembles that worked for nickel and copper at Sudbury, Ontario, Canada, which contains less than 3 per cent. of nickel and about the same amount of copper, together with small quantities of cobalt, silver, gold and platinum.

By mechanical concentration, roasting and smelting the Sudbury ore is converted into a "matte" containing nearly 40 per cent. of copper and over 30 per cent. of nickel, and much

of it is exported in that state for final treatment. If power and fuel are available there is no reason why the copper, nickel and cobalt in British Central Africa ores should not be concentrated in the same manner, and a "matte" obtained which it would pay to export.

Specimen D, from Central Angoniland.—This was a lead ore containing galena, anglesite and quartz. An analysis showed the composition of this specimen to be as follows:—

		Per cent.
Lead	Pb (other than sulphate)	53·43
Lead sulphate	$PbSO_4$	32·63
Total metallic lead, 75·71		
Silver	Ag	0·072
Iron	Fe	0·30
Silica	SiO_2	5·25
Gold	Au	trace
Sulphur	S	8·28
Total sulphur, 11·16		

The silver in this ore amounted to 23·52 ounces troy per ton of ore, or 31·05 ounces per ton of lead.

This is a valuable ore of lead containing a fair amount of silver, and it could probably be worked at a profit if it occurs in sufficient amount and fuel is available at cheap rates.

The sample of galena subsequently sent appeared to be practically pure sulphide of lead. It was assayed for silver and yielded 24·75 ounces troy per ton of ore, corresponding to 28·59 ounces per ton of metal, which is rather less than that present in specimen D.

Specimen E, from the Blantyre District.—This consisted of nickeliferous pyrrhotite and a small amount of copper pyrites with norite rock. An analysis of the portion soluble in acids gave the following results:—

		Per cent.
Iron	Fe	19·61
Ferrous sulphate	$FeSO_4$	0·51
Total iron, 19·77		
Nickel	Ni	1·34
Cobalt	Co	0·02
Lead	Pb	0·01

		Per cent.
Copper	Cu	0·94
Manganous oxide	MnO	0·05
Lime	CaO	0·61
Magnesia	MgO	1·18
Alumina	Al_2O_3	1·21
Sulphur	S	12·90
Combined water, Moisture		0·77
Residue insoluble in acids		58·20

No gold was found. The specimen appeared to contain a trace of platinum, but a larger sample would be required to estimate the amount of this metal present. This is a nickel and copper ore similar to specimen C, but it also contains a considerable proportion of silicates. The latter could be separated mechanically if sufficient water and power are available. The silicate minerals present include labradorite-felspar, biotite mica, hypersthene, augite and diallage, the whole constituting a norite similar to those with which such ores are associated in Canada and to the basic members of the charnockite group of hypersthene rocks which Holland has described in India.

A careful examination of the localities where this rock is met with might result in the discovery of other ore deposits of a similar character.

Specimen F, collected in the West Nyasa District.—This was a sample of washed kaolin. The clay was white in colour but contained numerous flakes of mica. When baked it formed a compact "biscuit," in which, however, the mica was still more conspicuous than in the original material. When mixed with water it settled more quickly than good kaolin should, but remained in suspension long enough to enable the greater portion to be poured off, leaving the larger flakes of mica and quartz fragments behind, but the washed (elutriated) material thus obtained was still gritty to the touch.

Analyses were made, both of the material in the condition in which it was received and of the product obtained by elutriation.

		Original material. Per cent.	Washed product. Per cent.
Silica . . .	SiO_2 .	53·82	49·80
Titanium oxide .	TiO_2 .	0·96	1·02
Alumina . .	Al_2O_3 .	29·04	32·40
Ferric oxide .	Fe_2O_3 .	1·70	2·11
Magnesia . .	MgO .	0·16	0·11
Soda . . .	Na_2O .	0·38	—
Potash . .	K_2O .	3·06	—
Combined water .	H_2O .	9·34	—
Moisture . . .	.	1·66	—

After "washing" there is, it will be seen, a satisfactory reduction of silica and increase of alumina, but the iron remains very high, and would discolour any pottery baked from the material. This kaolin possesses therefore little commercial value, and could probably only be used locally for the manufacture of common brown earthenware.

Specimen G, from the Zomba District.—This specimen was found to consist of grains of quartz embedded in lateritic material. It was assayed for gold but none was found.

Specimen H, collected in the Zomba District.—This was a fragment of decomposed dolerite rock. An assay for gold was made with a negative result. It was also examined for nickel and cobalt, but yielded only 0·06 per cent. of the oxides of these metals taken together.

A microscopical examination showed the presence of labradorite-felspar in rod-like crystals, biotite mica, pale green secondary hornblende, calcite and magnetite. This material is of no commercial value.

Examination of Gem Stones.

The specimens were carefully examined by mineralogical methods, and crystals or fragments of the following substances were found:—

(*a*) *Avanturine-oligoclase-felspar or sunstone.*—Larger specimens with good iridescence would be of some commercial value.

(*b*) *Garnet.*—These are of no value, nor would larger specimens of the same type repay the trouble of searching for them.

(*c*) *Hypersthene.*—This is of no commercial value, but it is interesting as showing the occurrence of hypersthene rocks, probably similar to those referred to above (page 137).

(*d*) *Actinolite.*—This is of no economic value; it is probably derived from an actinolite schist.

(*e*) *Orthoclase felspar.*—Of no value.

(*f*) *Quartz.*—Of no value.

(*g*) *Jasper.*—These are minute and without good colour. Jasper is of no value unless in large specimens with brilliant tints.

COTTON FROM BRITISH EAST AFRICA.

SAMPLES of five varieties of cotton, including ginned and unginned specimens of each, were recently forwarded to the Imperial Institute by the Director of Agriculture for the East Africa Protectorate, together with a Memorandum on their cultivation.

These samples have been submitted to examination in the Scientific and Technical Department of the Imperial Institute, and have been referred to commercial experts for valuation. An account of the results of the investigation is given below.

Sample labelled "No. J. 6, Lamu Cotton."

The following interesting particulars relating to this cotton were supplied by the Director of Agriculture in the Memorandum referred to above.

The plant which yields this cotton is a variety of *Gossypium herbaceum*, which was probably introduced into East Africa from India at an early date, and has long been grown on the Bajoon Coast. The quantity of cotton fibre produced in this district amounts to about six tons per annum, part of which is used locally for stuffing pillows, and part is exported to India. The cotton is planted in April, and the crop is gathered from October to January. The seed is sown on sandy soil, in holes

about three feet apart, in some cereal crop or in sesamé; after the latter crop has been harvested the cotton is left on the land, but receives no further cultivation. Cotton is collected from the same plants for at least five years, but owing to the growth of weeds and bush, the plants gradually become fewer in number, and finally disappear. The average yield of cotton is probably less than 100 pounds per acre.

The large amount of leaf and boll fragments in the cotton is due to the method of collection. The whole capsules are gathered, and the cotton, after being roughly removed, is beaten on a mattress, when the greater part of the dry leaves and capsules are powdered and fall to the ground. The cotton is then ginned by means of a pair of small wooden rollers. The cotton is sold at about 2½*d.* per pound.

The samples consisted of 2 pounds of ginned cotton and 1 pound of the unginned product. Both specimens, especially the unginned, contained a large amount of fragments of leaves and bolls. The seeds were very small and closely invested with short, white downy hairs. The cotton was white with numerous buff-coloured stains; it was harsh, of fair strength, and 0·6 to 0·9 inches long.

This fibre would not be of much value for spinning alone, but could be used for mixing with cotton of a higher grade.

The commercial experts reported that the ginned cotton was of too low a quality to class, but was perhaps worth 1*d.* per pound.

Sample labelled "No. J. 7, Fort Hall Cotton."

It is stated in the Memorandum furnished by the Director of Agriculture that this cotton is probably derived from an American variety. The cotton was grown experimentally by H.M. Sub-Commissioner on damp, shallow, dark loam; it was planted in December 1903, and harvested in June 1904.

The sample consisted of about one pound of ginned and one pound of unginned cotton. The seeds were dark brown in colour and bore a small white tuft at the pointed end; in some cases they were covered with a light brown or brownish green down. The cotton was of bright appearance, was cream-coloured, fairly soft, of rather poor strength and from 1·0 to 1·5 inches long.

The commercial experts reported that the cotton was, on the whole, of good silky staple, but somewhat mixed and worth $4\frac{1}{2}$*d.* per pound, "Middling American" cotton being quoted at $4\frac{1}{4}$*d.* per pound on the same date.

Sample labelled "No. J. 8, Kibwezi Cotton, Afifi."

This product was stated to have been grown from Egyptian seed by an Arab at Kibwezi, by means of irrigation on shallow rocky soil. The cotton was planted in March and harvested in September. The plants were healthy and produced a large number of capsules.

The samples consisted of 3 pounds of ginned cotton, and $1\frac{1}{2}$ pounds of the unginned material. The unginned cotton was fairly clean but was to a large extent unripe. The seeds corresponded to those of Egyptian "Mitafifi," but a considerable portion terminated in a sharp point and resembled the seed of the so-called "Hindi" cotton, the old white cotton of Egypt, which commonly occurs associated with "Mitafifi" and lowers the value of that product. In Egypt it is the custom on selecting the seeds for sowing to reject all these sharp-pointed seeds.

The sample was of uneven colour with occasional brown stains; the fibre was of very irregular strength, fairly soft to the touch, and 1·0 to 1·3 inches long.

The commercial experts reported that the cotton was deeply stained, but of fair staple, and worth about 3*d.* per pound, "Fully good fair brown Egyptian" cotton being quoted at $6\frac{1}{8}$*d.* per pound on the same date.

Sample labelled "No. J. 9, M'hindi Cotton, Malindi."

This cotton is said to be a variety of *Gossypium peruvianum.* The plants occur singly on the coast, and also grow at Voi and Tsavo. The tree is grown as a perennial, and very little cotton of this variety is produced.

The sample consisted of 1 pound 3 ounces of unginned cotton and 1 pound of ginned cotton. The cotton was of the "kidney" variety, the black seeds being united in groups of about seven. The cotton was easily detached from the seeds, and was of uneven colour, being cream-coloured with occasional reddish-

brown stains. The fibre was fairly soft, of poor strength, and 0·9 to 1·2 inches long.

The commercial experts reported that the sample was of very good staple, but contained a good deal of "dead" cotton (*i. e.*, cotton which is immature and unable to retain dyes), and was worth about 4⅜*d.* per pound, "Middling American" cotton being valued at 4¼*d.* per pound on the same date.

Sample labelled "No. J. 10, *Kisumu Cotton."*

This sample consisted of 1½ pounds of unginned and 2 pounds of ginned cotton. The cotton appeared to consist of two distinct varieties, the fibre of one being white whilst that of the other was reddish. The reddish cotton had dark brown seeds bearing a small, greenish tuft, whilst the white cotton had black, sharply-pointed seeds like those of "Hindi" cotton.

The ginned cotton was of a pale reddish colour with occasional brown stains. The fibre was soft to the touch, of irregular strength, and 1·0 to 1·3 inches long.

The commercial experts reported that the cotton was of very hard staple, and was worth about 5*d.* per pound, "Fully good fair brown Egyptian" cotton being quoted at 6⅛*d.* per pound on the same date.

In conclusion, the results of this investigation prove that these cottons are, on the whole, of promising quality, but that they show evidence of lack of care in cultivation. If more care were employed, particularly in the selection of seed for sowing and in the harvesting of the cotton, there can be no doubt that a product could be obtained which would be readily saleable in the English market.

FURCRÆA GIGANTEA FIBRE FROM INDIA.

THIS sample of Furcræa fibre (Regd. No. 21,256) was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, with a request that it might be submitted to chemical examination, and that its commercial value might be ascertained.

The sample of fibre was labelled "*Furcræa gigantea*, from Sambalpur Jail, through the Superintendent of the Royal Botanic Gardens, Sibpur." The product was of a pale buff colour and of fair strength, but had not been well cleaned. The length of staple varied from 4½ to 5 feet.

On chemical examination it gave the following results, to which are added for comparison those yielded by other samples of this fibre which have been examined in the Scientific and Technical Department of the Imperial Institute:—

	Sample No. 21,256.	Sample from Southern India. No. 10,523.	Sample from British Central Africa.	Sample from Grenada.	Sample from Victoria.
Moisture, per cent.	10·4	9·8	8·7	10·2	11·6
Ash, per cent.	2·2	—	1·1	2·4	2·3
α-Hydrolysis, loss per cent.	28·4	12·4	10·0	14·9	13·0
β-Hydrolysis, „ „	30·1	14·5	14·5	22·0	23·5
Mercerisation, „ „	16·8	11·4	8·7	16·0	16·2
Acid purification „ „	4·4	1·7	1·7	3·8	5·6
Nitration, gain per cent.	26·6	40·7	38·1	34·0	34·0
Cellulose, per cent.	66·9	77·7	75·8	77·8	72·2
Length of ultimate fibre	1·5–3·5 mm. or 0·06–0·14 inch.	2·5 mm. or 0·08–0·2 inch.	2·5 mm. or 0·08–0·2 inch.	1·5 mm. or 0·04–0·2 inch.	1·3 mm. or 0·04–0·12 inch.

These results indicate that the quality of the present sample of Furcræa fibre is somewhat inferior to that of the other specimens. This is shown especially by the greater action exerted upon the material by alkali, as demonstrated by the loss of weight sustained in the processes of hydrolysis and mercerisation. The percentage of cellulose and the increase of weight on nitration, which are rather lower than in the other cases, point in the same direction. There can be little doubt that the comparatively poor quality of this sample is largely due to defective preparation. This conclusion is supported by the fact that the greater part of the loss of weight produced by the hydrolysis of the fibre takes place in the α-hydrolysis, that is, during the first five minutes of its exposure to the action of hot alkali, and is due rather to the extraction of gummy matter—which ought to have been removed in the process of preparation—than to attack of the actual fibre substance. The further loss occasioned by the β-hydrolysis, which lasts for an hour, is comparatively small. It thus appears probable that by the

exercise of more care in the preparation of this fibre a considerable improvement in its quality and value could be effected.

In a trade report on this sample of fibre it was stated that the product was soft, of fair colour, of good length, fairly strong, but not well cleaned, and worth from £18 to £20 per ton.

AGAVE FIBRES FROM INDIA.

THESE samples of Agave fibres (Regd. Nos. 22,443 and 21,257) were forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, with a request that they might be submitted to chemical examination and that their commercial values might be ascertained. It was stated that the botanical identity of the species from which sample No. 22,443 was derived had not yet been completely established.

Fibre of Agave species.

The specimen of the fibre examined weighed about one pound, and was labelled "No. 22,443, Agave species, from the Royal Botanic Gardens, Sibpur." The product was of excellent colour, had been fairly well prepared but imperfectly cleaned, was of moderate strength, and had an average length of staple of five feet. The length of the ultimate fibre varied from 1·2 to 2·7 mm. (0·05–0·11 inch), with an average of 2·1 mm. (0·08 inch).

The results of the chemical examination of this fibre are given below, together with those of several samples of the fibre of *Agave rigida*, which have also been examined in the Scientific and Technical Department of the Imperial Institute.

	Agave species No. 22,443.	*Agave rigida fibre.*			
		Sample No. 8,327 from Saharanpur.	Sample from Bahamas.	Sample from Trinidad.	Sample from New South Wales.
Moisture, per cent. . . .	10·7	9·1	12·8	11·6	9·8
Ash ,, . . .	1·7	0·8	4·4	1·0	1·6
α-Hydrolysis, loss per cent.	10·0	8·6	12·0	11·7	13·0
β-Hydrolysis, ,, ,,	12·6	15·1	16·1	13·5	15·0
Mercerisation, ,, ,,	8·2	12·3	13·4	8·9	12·2
Acid purification, loss per cent.	1·0	1·6	8·1	1·0	5·6
Nitration, gain per cent.	28·8	37·5	29·7	32·9	34·1
Cellulose, per cent. . . .	73·8	82·4	75·9	77·2	77·7

These figures show that the present sample of fibre is, on the whole, of good quality and compares favourably with samples of *Agave rigida.* The comparatively small losses produced on hydrolysis and mercerisation prove that it is more resistant to the action of alkali than the other specimens, and is therefore likely to be more durable. On the other hand, the percentage of cellulose and the increase of weight on nitration are somewhat lower than those usually given by the fibre of *Agave rigida.*

Fibre of Agave rigida (No. 21,257).

This sample of fibre, labelled "No. 21,257, *Agave rigida*, from Sambalpur District, Central Provinces," was of a pale buff colour and fairly strong but imperfectly cleaned. The length of its staple was about 4½ feet; that of its ultimate fibres varied from 1·3 to 2·2 mm. (0·05–0·09 inch), with an average of 1·6 mm. (0·07 inch).

The results of the chemical examination of this specimen are given in the following table, together with those of other samples of the fibre of *Agave rigida* which have been examined in the Scientific and Technical Department of the Imperial Institute.

	Sample No. 21,257.	Sample from Saharanpur No. 8,327.	Sample from Bahamas.	Sample from Trinidad.	Sample from New South Wales.
Moisture, per cent. . . .	11·0	9·1	12·8	11·6	9·8
Ash, ,, . . .	3·6	0·8	4·4	1·0	1·6
α-Hydrolysis, loss per cent.	19·6	8·6	12·0	11·7	13·0
β-Hydrolysis, ,, ,,	21·9	15·1	16·1	13·5	15·0
Mercerisation, ,, ,,	12·5	12·3	13·4	8·9	12·2
Acid purification, loss per cent.	2·5	1·6	8·1	1·0	5·6
Nitration, gain per cent. .	30·5	37·5	29·7	32·9	34·1
Cellulose, per cent. . . .	67·1	82·4	75·9	77·2	77·7

A comparison of these figures shows that the present sample suffers an unusually large loss in the process of hydrolysis, the greater part of which occurs during the first five minutes (α-hydrolysis). The percentage of cellulose is correspondingly low. The comparatively poor quality of this specimen is no doubt largely due to the presence of gummy matter, owing to defective preparation. The results of this investigation indicate that the quality and value of this fibre could be considerably enhanced by the exercise of greater care in its extraction and preparation for the market.

The fibre of *Agave species* (Sample No. 22,443), was reported by one firm of fibre brokers to be of good length and colour, fairly well prepared, clean, fairly strong, similar to Sisal hemp, and worth from £26 to £28 per ton. A second firm, however, considered that its value was only £20 to £21 per ton.

The fibre of *Agave rigida* (Sample No. 21,257) was reported to be of good colour and fair length, harsh but fairly well cleaned. The commercial value of this material was estimated at from £15 to £18 per ton.

RUBBER FROM THE SOTIK FOREST, EAST AFRICA PROTECTORATE.

THIS sample of rubber, together with a botanical specimen of the plant from which it was obtained, was forwarded to the Imperial Institute by the Director of Agriculture in the East Africa Protectorate. In the accompanying letter the rubber was stated to have been collected in the Sotik Forest, and, with the object of facilitating the botanical identification, the following description was furnished of the flowers of the plant yielding it:—"The corolla is dark red, inflated below the middle; the stamens are inserted above the widened part of the corolla tube."

Botanical Source of the Rubber.

The single botanical specimen of the plant was transmitted to the Director of the Royal Botanic Gardens, Kew, for identification. He reported that the material was insufficient to permit of a satisfactory identification, but stated that the plant was a Landolphia, and that the flower closely resembled that of *Landolphia ugandensis*. The previous specimens of rubber vines forwarded from the East Africa Protectorate to the Imperial Institute have been identified as *Landolphia watsoniana*, *Landolphia petersiana* and *Landolphia Kirkii* (see *Bulletin of the Imperial Institute*, Vol. i., 1903, pp. 68 and 70, and Vol. ii., 1904, pp. 153 and 221). Comparatively little is known regarding *Landolphia ugandensis* as a source of rubber, and for this reason the examination of the present specimen presents special interest.

Description of Sample.

The sample of rubber consisted of two balls, together weighing 55 grams (1·9 ounces). Externally the balls were black, but when cut they were found to be almost white internally, and to contain a considerable quantity of foreign vegetable matter. The rubber was somewhat soft, but exhibited good elasticity and tenacity, and was free from stickiness.

Chemical Examination.

The rubber was soluble in chloroform, benzene and carbon disulphide, and partially soluble in ether. On analysis it gave the following results:—

	Material as received. Per cent.	Calculated for dry material. Per cent.
Caoutchouc (true rubber)	78·3	83·5
Resin	9·1	9·7
Moisture	6·2	—
Dirt and insoluble matter	6·4	6·8
Ash (included in "Dirt")	2·4	2·5

These results show that, so far as chemical composition is concerned, this rubber is of good quality, since when dry it contains nearly 84 per cent. of caoutchouc. The amounts of resin and dirt are rather high, but the percentage of the latter could be reduced by more careful collection and preparation.

The high percentage of resin may be characteristic of the rubber yielded by this plant, or it may be due to the present specimen having been collected from young vines. In the latter case it is probable that better rubber would be obtained from more mature vines.

Commercial Valuation.

The rubber was submitted for criticism and valuation to commercial experts, who were informed of the results of its chemical examination. They described it as "fair black-coated ball, rather wet and slightly barky, worth about 3*s.* to 3*s.* 6*d.* per lb., and readily saleable."

RUBBER OF *FICUS ELASTICA* FROM THE MADRAS PRESIDENCY.

THIS sample of rubber was forwarded for examination and valuation to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, and was stated to have been obtained from *Ficus elastica* trees cultivated at Parlakimedi, Ganjam District, Madras.

The specimen consisted of a single flat cake weighing 60 grams (2 ounces). The rubber was black externally, but when the cake was cut open it was found to be white at the centre, the colour gradually darkening towards the surface. The rubber was fairly tenacious and elastic, somewhat moist but not sticky; it contained a small amount of visible impurity, consisting principally of vegetable débris.

Chemical Examination.

The rubber was examined in the Scientific and Technical Department of the Imperial Institute, and gave the following results:—

	Material as received. Per cent.	Calculated for dry material. Per cent.
Caoutchouc (true rubber)	85·2	88·6
Resin	7·8	8·1
Albuminoid matter	1·4	1·4
Moisture	3·7	—
Dirt and insoluble matter	1·9	1·9
Ash (included in "Dirt," etc.)	0·5	0·5

These results show that the sample is of good quality, as the dry material contains over 88 per cent. of true rubber. The percentage of resin is a little higher than is desirable, but is lower than the amount frequently found in *Ficus elastica* rubber.

Commercial Valuation.

A sample of the rubber was submitted to commercial experts for criticism and valuation. They described it as "clean, strong rubber, worth from 3*s.* 6*d.* to 3*s.* 9*d.* per lb.," good quality Assam rubber derived from *Ficus elastica* being quoted at the same time at 3*s.* 7½*d.* per lb., and the best qualities of Para rubber from South America at 5*s.* 2*d.* per lb.

GARCINIA RESIN FROM PERAK, FEDERATED MALAY STATES.

THIS material was forwarded to the Imperial Institute on behalf of the Government of the Federated Malay States by Mr. Leonard Wray, Curator of the Perak Museum. The specimen was accompanied by a letter giving the following information with regard to the extraction and preparation of the resin :—

"The resinous substance is the dried sap of a *Garcinia.* The sap is obtained by making incisions in the bark of the trees. It is then boiled until it is as thick as cream, when a little turpentine is added, and it is ready for use as varnish, being applied to the wood by means of a pad of cloth.

"As prepared it is an emulsion of a pale yellow colour; if boiled till all the water is evaporated it solidifies, and cannot be dissolved again with turpentine, but if water is added at once it may again be made into an emulsion. It will only keep in good condition for a few days, fermentation of the watery portion of the sap readily setting in.

"This Malay varnish is, when dry, nearly white, very hard and brilliant, being quite equal to the Japanese lacquer. The tree which yields it is a wild one, and as it fruits freely there should be no difficulty in planting it."

Chemical Examination.

The sample of this product forwarded has been examined in the Scientific and Technical Department of the Imperial Institute. The specimen weighed about 4 ounces, and consisted of a semi-solid resin contained in a portion of a bamboo stem. Internally the material was soft and opaque, and had a pale yellowish colour, and an odour resembling that of "t'ung" oil, but externally it was dark-brown in colour, and was covered by a very thin layer of brittle material, probably produced by the action of the atmosphere on the resin. This hard outer layer, which is probably identical with the insoluble resin produced by evaporating the whole of the water from the sap, constituted only a minute proportion of the whole; it was insoluble in turpentine oil and the usual solvents, but the small amount obtainable precluded its further investigation.

The resin, when freed from the thin outer layer of altered material, was soluble in turpentine oil, chloroform, benzene, and ether, and almost completely so in alcohol. It melted at 65° C. (159° F.), and on ignition furnished 0·21 per cent. of ash. One grain of the resin required 89·2 milligrams of potassium hydroxide for neutralisation, and 93·5 milligrams of this re-agent for complete saponification. It contains, therefore, a large proportion of free resin acids, and a comparatively small amount of resin esters.

When dissolved in turpentine oil and the solution applied as a varnish to wood, there was left on drying a hard almost white "coat," similar to that produced by damar varnishes.

A small sample of the resin was submitted to a firm of varnish makers for technical trial; they reported that it could probably be used as a substitute for damar resin in the preparation of varnishes suitable for indoor work, but that it would be necessary to carry out experiments on a large scale before a definite commercial value could be assigned to the material.

These results indicate that this Garcinia resin is a product of considerable interest and likely to prove commercially valuable, and it has been suggested that a larger sample of about fourteen pounds of the material should be prepared and forwarded to the Imperial Institute for further examination, technical trial and commercial valuation.

At the same time a similar sample of the hard insoluble resin prepared by evaporating the whole of the water from the sap, as described in the letter accompanying the present specimen, has been requested, since it is possible that a process might be devised for preparing a resistant varnish of the copal type from this material.

It is desirable that steps should be taken to identify the particular species of *Garcinia* from which this resin is derived. In this connection it is of particular interest to note that this resin appears to be quite different in constitution from the gum-resin, gamboge, obtained from the nearly allied plants *Garcinia Hanburii* and *Garcinia morella*.

GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

OCCURRENCE AND USES OF MINERALS CONTAINING THORIUM.

THE discovery of an important source of thoria available for use in this country in the new mineral thorianite, and the possibility of this material being used in the manufacture of incandescent mantles, has created considerable interest (this *Bulletin*, Vol. ii., p. 13). A large number of inquiries on the subject has been received at the Imperial Institute, and it has therefore been considered advisable to publish the following general statement on the subject.

The commercial importance of minerals containing thorium is due to the demand for thoria (oxide of thorium), a substance which is used extensively in the manufacture of the mantles employed in incandescent gas lighting.

Thorium minerals are comparatively rare, and as a rule contain only a small amount of that element. Further, the amount of thorium in a mineral is generally not a fixed quantity for any particular species, since certain other elements can replace without altering the specific character of the mineral concerned.

The following list comprises the best known minerals which may be regarded as sources of thorium :—

	Thoria (Thorium dioxide). Per cent.
Thorianite	70–78
Thorite	48·6–71·6
Thorogummite	41·4
Æschynite	15·7–17·5
Naëgite	16·5
Monazite	1·2–14·2
Uraninite	1·6–9·7
Pyrochlore	4·9–7·5
Polymignite	3·9
Samarskite (variety)	3·19–3·6
Allanite	traces–3·4
Xenotime	0·49–3·3
Ånnerödite	2·3
Gadolinite	traces–0·8

Of these minerals only monazite has hitherto been found in such quantities as to make the commercial extraction of thoria possible, and practically all the thoria of commerce is derived from monazite at the present time. Thorite, however, has been found in fairly large quantities at Arendal, in Norway, and its supply is said to have interfered occasionally with the trade in monazite.

The mineral, thorianite, found in Ceylon, has so far not been recorded outside that island, where its mode of occurrence and distribution are at present being investigated. The remainder of the minerals in the above list are of rare occurrence, and for the most part poor in thoria.

Monazite.

Monazite is a rock-forming mineral, and as such is found in the form of small monoclinic crystals in certain granites, gneisses and syenites. The larger crystals are found in the coarse-grained veins of so-called "pegmatite" which traverse these rocks. It also occurs in consolidated sedimentary rocks of cretaceous age on the coast of Brazil, but in this case the rocks have probably been derived from the transported weathering products of older granites and gneisses. When these granites and consolidated sediments are broken up by the ordinary processes of denudation, the resistant minerals—quartz, zircon, ilmenite, magnetite, and monazite—are washed into streams and rivers, where they are distributed in varying degrees of concentration at different parts of the stream bed. The heavy minerals, such as monazite, ilmenite, etc., are deposited first, and generally the richest portions are found near the head waters. In the case of the Brazilian shore deposits, where the monazite is derived from the sandstones which form bluffs on the sea coast, the rock is broken up *in situ* by the action of the sea, and the shattered material is distributed along the coast. In this way the disintegration of the bluffs keeps up a constant supply of fresh material, which is often sorted and concentrated by the waves in such a way as to be ready for immediate shipment.

Monazite crystallises in the monoclinic system. Its colour varies from yellow to brown, the grains being generally yellow

and transparent, though sometimes rendered turbid by reddish-brown decomposition products. The lustre is vitreous in small grains and somewhat resinous in large fragments. The hardness ranges from 5 to 5·5, and the specific gravity from 4·9 to 5·3. The refractive index is high (1·81), and birefringence very strong ($\gamma - \alpha = 0{\cdot}046$). In sands monazite generally occurs in the form of oval grains, though occasionally its crystal faces are well preserved. The mineral appears to be universally associated with zircon, and generally also with ilmenite. Other minerals found commonly in association with it are magnetite, tourmaline, garnet, xenotime, sphene, kyanite, rutile, brookite, anatase, and cassiterite.

The chemical composition of monazite appears not to be definitely settled. Some authorities regard it as being essentially a cerium phosphate, in which the cerium may be replaced by didymium, lanthanum and thorium, whilst others regard it as a mixture of cerium, lanthanum and didymium phosphates, with thorium silicate as an impurity. As a matter of fact monazite always contains some silica, but this is not invariably in the proportion required to form thorium silicate with the thoria present.

Monazite is liable to be confused with yellow grains of quartz, also with grains of epidote, zircon, and sphene. It is readily distinguished chemically from these by the fact that it dissolves in sulphuric acid and gives the phosphate reaction with a nitric acid solution of ammonium molybdate. Its inferior hardness and high specific gravity are characteristic features, which are helpful in identification.

Monazite is widely, though not plentifully, distributed. It has been found in the United States, in Canada, several parts of South America and Australia (New South Wales and Queensland). In Europe it is recorded from France, Germany, Russia, Belgium, Norway, Sweden, Switzerland, Austria, and England (Cornwall). It has been discovered recently in the course of the mineral survey now being carried out in Southern Nigeria, under the direction of the Imperial Institute, to be fairly widely distributed in that Protectorate, and the quality of the sands obtainable there is now being investigated. The mineral has also been recognised at the Imperial Institute in certain alluvial

deposits occurring in the Malay Peninsula. The most important localities, and those which have hitherto supplied the commercial demand for monazite, are the deposits in Brazil and in North and South Carolina. A small amount is obtained from the "pegmatite" dykes of South Norway, where it is said to be a by-product from felspar mining.

BRAZIL.—Here monazite is fairly common in the granites, syenites, and gneisses; there does not, however, appear to be any record of its occurrence in the streams and rivers of the interior, though one would expect them to yield a considerable amount, having regard to its abundance in the underlying rocks. According to Branner, it occurs in cretaceous sediments along the coast, and it is from these that the shore deposits are derived. This fact is important in considering the future of the Brazilian coast trade in this material, since the shore deposits will be replenished more rapidly from the disintegration of sedimentary shore bluffs than they would be from granite cliffs or by the feeding action of rivers.

The quality of the shore deposits varies from place to place, in some places being very rich, and in others comparatively poor. The natural concentration of the heavy monazite due to the complex action of waves and currents is an important feature in the exploitation of the deposits. Occasionally these natural concentrates average 90 per cent. of monazite, and in this condition they are said to have been sold occasionally in Europe at less than £10 per ton (two cents per lb.). The export from Brazil in 1902 amounted to 811 tons, valued at £16,200.

NORTH AND SOUTH CAROLINA.—Here the monazite occurs in granites and gneisses, and it is found in a more or less concentrated condition in the streams which drain the areas where these rocks are weathering at the surface. Mezger states that in many places the rock will pay for crushing and concentrating. It seems to be worked, however, only in the richer portions of the stream deposits. Here the sands are concentrated in a rough way by washing in sluice boxes after the coarse gravel has been screened off. The lighter constituents are washed off from the sluice boxes, and a concentrate thus obtained, consisting largely of monazite, associated with zircon, ilmenite and garnet. The crude

concentrate is sometimes further purified by the miners themselves, but more often it is sold to the various companies in the district, who own elaborate concentrating plants. The Carolina monazite is said to be coarser in grain than that of Brazil, and less uniform in grade. The preliminary washings seem to be carried on largely by farmers as an incidental source of income.

The amount of monazite produced in the United States in 1903 was estimated at 385 tons, valued at about £12,900.

Thorianite.

This mineral, originally confused with pitchblende, but shown by examination at the Imperial Institute to be a thorium compound (see "Reports on the Results of the Mineral Survey of Ceylon in 1903-4," (Cd. 2,341), and "Thorianite, a New Mineral from Ceylon," Dunstan and Blake, *Proceedings of the Royal Society*, 1905), has a sub-metallic lustre, and is dull black on weathered surfaces, but bright when freshly fractured. It gives a brownish streak with a slight tinge of green. It apparently crystallises in the cubic system, and generally occurs in the form of cubes, which sometimes show interpenetrant twinning, as in the case of fluorspar. It has a hardness of about 7, so that it scratches glass, but not easily. Its specific gravity when pure is about 9·5, but some specimens have a specific gravity as low as 8. The variation in density is due partly to inclusions of other minerals and partly to decomposition; specimens are commonly somewhat porous, the pores containing a yellow ochreous material, which is apparently a decomposition product.

Thorianite is infusible in the blowpipe flame, but decrepitates and gives off bright scintillations. It shows uranium reactions in borax and microcosmic beads; these are best seen with microcosmic salt, in which case the bead is a distinct green colour in the reducing flame, whereas iron under these conditions would be colourless. On fusion with carbonate of soda, and heating the fused mass with hydrochloric acid in the presence of metallic tin, the solution does not yield the colours characteristic of titanium (violet), tungsten (blue), or niobium (blue); by this means thorianite can be distinguished from such minerals as ilmenite, wolfram, fergusonite, etc. It is characteristic of

thorianite to have yellowish-brown thorite-like patches on it, and the presence of these is often a useful guide in identifying fragments of an irregular shape. It is only very slightly magnetic; the poles of an electro-magnet can therefore be easily adjusted to pick up ilmenite and leave thorianite behind.

The minerals most commonly associated with thorianite are ilmenite, zircon and spinel, but it can be distinguished readily from these by moderately careful determination according to the above-mentioned characters.

A good way of estimating the amount of thorianite in a given sample containing much ilmenite, zircon, etc., is by the use of fused lead chloride. Lead chloride melts at 485° C., yielding a liquid which has a specific gravity of 5, and in which zircon, ilmenite, and spinel float, while thorianite sinks. This separation can be made in an ordinary test tube. On cooling, the fused mass is easily extracted and readily broken across, so as to separate the part containing the thorianite from that with ilmenite, etc. The lead chloride can be dissolved off the thorianite in boiling water to which acetic acid has been added. By this means the approximate percentage of thorianite in any given sample is readily obtained.

In all cases the thorianite thus obtained should be carefully examined to ensure its purity. Cassiterite (tinstone) sometimes occurs with it, and it also sinks in fused lead chloride. It is advisable to separate the ilmenite first by means of an electro-magnet, as by this means the bulk is considerably reduced.

In composition thorianite is essentially a mixture of thorium and uranium oxides.

The following are the results of the analysis of two different specimens of this mineral, made in the Scientific and Technical Department of the Imperial Institute:—

		(1) Per cent.	(2) Per cent.
Thorium Oxide	ThO_2	72·24	76·22
Cerium Oxide	CeO_2	6·39	8·04
Lanthanum and Didymium Oxides	La_2O_3 & Di_2O_3	0·51	
Zirconium Oxide	ZrO_2	3·68	trace
Uranium Oxide	UO_3	11·19	12·33
Ferric Oxide	Fe_2O_3	1·92	0·35
Lead Oxide	PbO	2·25	2·87
Silica	SiO_2	1·34	0·12
Insoluble Residue		0·41	—

Specimen No. 1 had a specific gravity 8·98, and contained inclusions of zircon. No. 2 was a purer specimen, and had a specific gravity 9·32.

Thorianite has only been found sò far in certain gem gravels of Ceylon.

Thorite.

The colour of this mineral varies from orange-yellow through brown to black, and the lustre is generally resinous. The crystal form resembles that of zircon and belongs to the tetragonal system. The cleavage is distinct and parallel to the faces of the prism; the fracture is conchoidal.

The hardness of the mineral varies from 4·5 to 5 and the specific gravity from 4·32 to 5·40. In composition thorite is essentially a thorium silicate, but generally contains water, and often also uranium and iron. It is found chiefly in Norway and its occurrence has also been noted in Ceylon.

Thorogummite.

This is a variety of gummite very rich in thorium (gummite generally contains from 60 to 75 per cent. of uranium oxide, and is regarded us an alteration product of uraninite). The mineral is dull yellowish-brown in colour, and generally occurs in massive form; its hardness varies from 4 to 4·5 and the specific gravity from 4·43 to 4·54. Thorogummite becomes dull green after ignition, and is then easily soluble in nitric acid. It is found associated with fergusonite at the gadolinite locality in Llano Co., Texas.

Æschynite.

The colour of this material is dark brown to black; its lustre is resinous, fracture conchoidal, and the crystals belong to the rhombic system. The hardness varies from 5 to 6, and the specific gravity from 4·93 to 5·23. Æschynite is essentially a niobate, titanate and thorate of the cerium metals. It is found in the gold sands of the Urals, and also occurs in granite in Norway and Silesia.

Naëgite.

This mineral is dark green when fresh, and apparently turns brown through alteration. It is tetragonal, has a hardness of

7·5 and a specific gravity of 4·09. Besides thorium, the chief constituents are silica and uranium. It is found in Japan.

Uraninite (*Pitchblende*).

This mineral is black in colour and gives a brownish-black streak. The lustre is generally submetallic and the crystals belong to the cubic system, although the mineral generally occurs massive.

The hardness is 5·5 and the specific gravity varies from 9·0 to 9·7; the latter character is sometimes greatly diminished as the result of alteration. The composition of pitchblende is very complex, but is mainly uranium oxide, with varying amounts of lead and thorium and small quantities of many other elements. It is found in many localities in Europe and America.

Pyrochlore.

The colour varies from brown to brownish-black. The lustre is vitreous to resinous and the fracture conchoidal. The mineral crystallises in the cubic system, commonly in the form of octahedra. The hardness is from 5 to 5·5 and the specific gravity from 4·2 to 4·36. In composition pyrochlore is chiefly a niobate of the cerium metals, calcium and other bases, and also contains titanium, thorium, and fluorine. It is found at Miask in the Urals, and at several localities in Norway.

Polymignite.

This mineral is black in colour with a dark brown streak, the fracture is conchoidal, the lustre submetallic, and the crystals belong to the rhombic system. The hardness is 6·5 and the specific gravity varies from 4·77 to 4·85.

Polymignite is a niobate, titanate, and zirconate of the cerium metals, iron and calcium; it is found mainly in Norway.

Samarskite.

This mineral does not generally contain thorium, but a mineral closely related to it, and included under it by Dana, has been found in Colorado, which contains over 3 per cent. of thoria. Its colour is pitch-black in the mass, and pale brown in thin splinters. The fracture is conchoidal, the lustre vitreous,

and the streak dirty brown. The mineral is very brittle, has a hardness of 5·5 to 6 and a specific gravity of 6·18.

Allanite.

The colour of this mineral varies from brown to black. The crystals belong to the monoclinic system and are isomorphous with those of epidote. The lustre may be vitreous, resinous or submetallic. The streak is grey with occasionally a greenish or brownish tinge; the fracture is uneven or conchoidal, the hardness 5·5 to 6, and the specific gravity 3·5 to 4·2.

Allanite consists of silicates of calcium, aluminium and iron, with variable amounts of the rare elements cerium, lanthanum didymium, thorium, and yttrium. It is of fairly common occurrence as a rock-forming mineral, and is found as an accessory constituent in many igneous rocks.

Xenotime.

The colour of this mineral may be red, yellow or brown; the streak reddish or yellowish-brown and the lustre vitreous to resinous. It exhibits a perfect cleavage parallel to the prism, and shows an uneven or splintery fracture. It crystallises in the tetragonal system with forms resembling those of zircon in habit. The hardness is from 4 to 5 and the specific gravity 4·45 to 4·56.

In composition xenotime is essentially an yttrium phosphate. It occurs, like monazite, as a somewhat rare rock-forming mineral in certain granites and gneisses.

Ånnerödite.

This mineral is black in colour and shows a dark brown to brownish or greenish-grey streak; the lustre is sub-metallic and the fracture conchoidal. Its hardness is 6 and specific gravity 5·7 Ånnerödite is chiefly a pyroniobate of uranium and yttrium. It is found in a "pegmatite" vein at Ånneröd, in Norway, associated with monazite.

Gadolinite.

This mineral is brown to black in colour with a vitreous to greasy lustre and a greenish-grey streak; the fracture is

conchoidal or splintery. The mineral crystallises in the monoclinic system, but is often isotropic. It shows a hardness of 6·5 to 7, and has a specific gravity of 4·0 to 4·5.

Gadolinite is chiefly a silicate of yttrium, beryllium and iron, and is found in granite and granite veins in many localities, commonly associated with allanite.

COMMERCIAL UTILISATION OF THORIUM MINERALS.

As has already been stated, the thorium contained in the minerals described in the preceding paragraphs alone determines their commercial value, since although various uses have from time to time been suggested for a number of the associated constituents, these are of little importance from a commercial point of view. The only use to which thoria has been applied on a large scale is for the manufacture of mantles used in incandescent gas lighting, though quite recently various medicinal applications of thorium salts have been suggested. The utility of thoria in the gas mantle is due to the fact that it emits light, that is, becomes incandescent, at a comparatively low temperature.

The thoria for use in the manufacture of incandescent gas mantles is always put on the market in the form of the crystallised nitrate, and this is at the present time, as already stated, prepared almost exclusively from monazite, though lately thorianite has also been used as a source. The monazite and monazite sand of commerce are very complex mixtures; thus, a specimen of Carolina monazite was found to contain the following extraneous minerals:—tetradymite, brookite, quartz, anatase, chromite, corundum, tourmaline, pyrope, zircon, epidote, fibrolite, columbite, samarskite, xenotime, montanite, fergusonite, rutherfordite, talc, tremolite, magnetite, limonite, menaccanite, hæmatite, asbestos, cyanite, rutile and actinolite. The best washed monazite of commerce contains from 35 to 70 per cent. of cerite earths, from 0 to 5 per cent. of yttria earths, and from 0 to 9 per cent. of thoria, whilst the best monazite sand contains from 50 to 90 per cent. of monazite, equivalent to from 1·5 to 5 per cent. of thoria.

The details of the methods used in the commercial preparation of thorium nitrate from the mineral are not well known; but the following are outlines of processes which have been proposed from time to time.

The mineral is first treated with twice its weight of hot concentrated sulphuric acid, whereby the phosphates of the rare earths pass into solution. This process is greatly accelerated if the dry sand is introduced into the hot acid. The whole is heated slowly until the mass sets to a thick paste, when either the heating is continued to dryness, or the mass is allowed to cool and then extracted with cold water. The aqueous extract consists mainly of phosphoric and titanic acids, and the sulphates of cerium, thorium, yttrium and iron. The residue consists of the difficultly soluble silicates and silica, ilmenite and magnetite. More recently a method involving the electrical fusion of the sand with coke is stated to have been successfully applied. This process may be used with residues poor in thoria or directly with the sand. The fusion takes place in graphite crucibles of 0·75 litre capacity surrounded by fire-brick. The crucible itself forms the cathode; the anode is a carbon rod 40 mm. thick. Carbides (and some phosphides) of the rare earths are formed, from which soluble salts are readily obtained. The advantages of the method are its rapidity and the non-formation of phosphoric and silicic acids. Many methods for treating the solution obtained by either of these processes have been patented. According to Kosmann's process the solution is just precipitated by ammonia and then slightly acidified with hydrochloric acid. On treating with sulphuretted hydrogen and allowing to stand for twenty-four hours, the iron and aluminium are precipitated together with sulphur, and most of the didymium, if proper concentrations are employed. The solution is decanted, and ammonia, ammonium citrate and hydrogen peroxide added. This produces a precipitate consisting principally of thorium hydroxide, but still containing some alumina and cerite earths. Other processes consist in making use of the difference in solubility of the oxychlorides or sulphites of thorium and cerium.

In the preparation of the nitrate from the crude thoria thus obtained, the oxalate is first prepared. By precipitating

the thoria two or three times as oxalate, it is possible to obtain a product almost entirely free from cerium earths and other impurities. The oxalate is dissolved in strong nitric acid, diluted, and allowed to crystallise *in vacuo*. It is generally dried at 100° C., and then forms the "thorium nitrate" of commerce. This product should contain about 47·5 per cent. of thoria.

From the point of view of ease of extraction the new Ceylon mineral "thorianite" presents great advantages over monazite, since it may be directly converted into the nitrate by treatment with nitric acid.

The cerium oxalate produced as a by-product is also employed in the manufacture of gas mantles, which contain cerium oxide to the extent of 1 per cent. A small amount of this material is also used in medicine.

Mantles for incandescent gas lighting consist of an intimate mixture of 99 per cent. of thoria with 1 per cent. of ceria. They are made in the following manner:—

A cylinder of suitable length, made of "net" prepared from cotton, ramie, artificial silk, or other similar material, is taken, and the end sewn together by an asbestos thread. A loop of the same material is fixed across the constricted portion, as a means of support on the carrying rod, which is usually fixed centrally to the burner head. The fabric is soaked in a solution of thorium and cerium nitrates, mixed in the proportions of 99 to 1, until the microscopic fibres of the "net" are filled with the liquid. Owing to the acid nature of the solution, a longer soaking is undesirable, as it renders the fabric weaker and more difficult to handle. The mantle is mechanically squeezed to free it from the liquid adhering to the outside of the fibres, and is then stretched over conical moulds of the required shape and allowed to dry in a warm atmosphere. It is now ready for "burning off." On the proper carrying out of this process much of the ultimate success of the mantle depends. The flame of a burner is applied to the top of the mantle; the fibre gradually burns downwards, and the nitrates are converted into oxides. The shape of the mantle largely depends on the regularity with which the combustion takes place. A certain amount of carbon is generally

left behind, which is burnt off by means of a Bunsen flame. The process of "burning-off" is nearly always done by hand. Machines have been introduced for the purpose of performing the operation on a large number of mantles at once, but they give less satisfactory results. The very fragile "burnt-off" mantles are temporarily strengthened by dipping them in a solution of "flexile collodion." The collodion is burnt off by the consumer by applying a light to the bottom of the mantle.

Many substitutes for cotton, which was first employed for the construction of the "net," have been tried with varying success. Mantles made from artificial silk fibre (*Imperial Institute Bulletin*, 1904, ii, 266), have given good results, but the cost of production of the fibre is a drawback to its general use. The nitrates are well mixed in the "collodion" solution, which is passed through very narrow glass tubes of 0·01 mm. bore. Ten or twelve of such fibres are twisted into one thread, which is denitrated by one of the usual processes, forming a base of artificial silk impregnated with the nitrates of the earths.

A "burnt-off" thread of this nature appears under the microscope as a loose bundle of rods of oxide; that from cotton "net" shows a dense fluted column of oxide, surrounded by a spongy mass. This difference seems to account in a very large degree for the difference in the life of the mantles. A mantle made from an artificial silk fibre is stated to retain its light-giving power much longer than that from a cotton mantle.

A considerable improvement has been introduced during the last few years by the substitution of a naturally-occurring fibre—ramie—(*Imperial Institute Bulletin*, 1905, iii, 55), for cotton. This gives considerably more ash on burning than most cottons, and mantles made from it contract less in "burning-off" and are stronger than those made from cotton. Ramie, moreover, absorbs less of the rare earth mixture than does ordinary cotton.

In using incandescent mantles it is generally found that the illumination increases for a certain period, and that then a steady fall sets in. Irregular fluctuations in the illuminating power are also to be observed. These latter have been shown to be due to variations in the calorific power of the gas. The initial

steady rise is probably due to the gradual shaping of the mantle to the flame. The subsequent fall has been shown to be occasioned by two causes. Dust particles of silica are carried by the draught against the mantle, where they form, with the oxides, infusible silicates having a small emissive power. A more potent cause is the gradual volatilisation of the ceria, to which the whole of the incandescence is due. Some manufacturers have succeeded in greatly lessening the rate of loss of ceria, and their mantles retain their efficiency for very long periods. It has been shown, too, that the hygroscopic state of the atmosphere has a small though perceptible influence on the luminosity of a mantle.

The production of light by heating refractory bodies dates from the invention of the Drummond lime-light in 1826. Since that time up to the taking out of the first Welsbach patent in 1885, many attempts at producing a satisfactory incandescent light were made, and of these Clamond's mantle was probably the most satisfactory. It consisted of threads of calcined magnesia on a platinum cage, which was heated by a mixture of coal-gas and air under pressure. Auer von Welsbach's second patent, in 1886, covered the use of thoria alone or mixed with zirconia, yttria, magnesia, erbia, didymia, lanthana or alumina. The exact date when the importance of ceria was shown is not known. Haitinger found, on working with thoria, that the purer the thoria the less intense the light, and that quite pure thoria gave no light. His purification had consisted in a separation of the ceria earths. In 1890 incandescent gas lighting again became prominent, mantles consisting of 99 per cent. thoria and 1 per cent. ceria being demonstrated to be satisfactory. Such a composition is found to give a maximum illumination, and it is in general use at the present time.

The substitution of thoria by any of the other earths has been generally found to be deleterious, though a certain amount of success has been obtained with mantles consisting of a base of thoria and zirconia, dipped in a 99 : 1 thoria-ceria solution and ignited. In endeavouring to find a substitute for thoria, other points besides the power of light-emission must be considered. Some nitrates shrink too much when

converted into oxide. Thorium nitrate, on the contrary, swells considerably during the process; so much so, indeed, that if cerium nitrate is present the percentage of ceria by volume after ignition sinks as low as 0·1 per cent. Some oxides slowly volatilise; some undergo partial fusion; others give a coloured light. From all points of view, thoria at present stands unrivalled. One of its most valuable properties is its extremely small radiating power for heat. It is for this reason that it is able to attain so high a temperature, and this accounts very largely for the brilliancy of the light obtained.

There have been several theories to account for the influence of the very small amount of ceria on the light-giving properties of the mantle, and the matter cannot yet be said to have been definitely settled. The assertion of Auer von Welsbach that "the invention is founded, above all, on the fact, proved by numerous experiments, that molecular mixtures of certain oxides are possessed of properties which cannot be deduced from those of their constituents," is another way of stating the problem at issue, but affords no explanation of the fact.

Cerium is capable of assuming several states of oxidation, and von Welsbach has suggested the explanation that a very large number of alternate oxidations and reductions take place, which give rise to a series of molecular shocks, and hence to light-emission. Chromium, which also has two oxides, will behave similarly to cerium, with an alumina basis in place of thoria, and in this connection von Welsbach points out that thorium and cerium, and aluminium and chromium are isomorphously replaceable in many of their compounds. The very limited range in the amount of ceria that may be present seems to militate strongly against Welsbach's theory of the action.

Though comparatively small quantities of these oxides, thoria and ceria, are used in the construction of each mantle, the number of mantles used is so enormous that the total trade in monazite and in thorium nitrate attains a considerable volume. Unfortunately, owing to the specialised character of the manufacture of thorium nitrate, and as the result of the restricted range of distribution of monazite, the trade in these products has become to some extent a monopoly. From this point of view the discovery of thorianite and other thorium-bearing

minerals in Ceylon, and of monazite in Southern Nigeria, by the mineral surveys now being carried on in those countries by the Imperial Institute, is of great importance as affording new sources of thoria.

UTILISATION OF PEAT.

PEAT or turf is the product of the slow decay of plants under conditions in which the supply of air is limited. It is formed chiefly from the mosses of the genera *Sphagnum* and *Hypnum*. Each year the old growth is succeeded by a new crop of similar plants, until finally a thick layer of vegetable matter collects, which undergoes slow decomposition with the evolution of marsh-gas, carbon dioxide and other gases, and though the surface may be green the decayed portion beneath presents a dark earthy colour. Many of the localities where peat deposits are now found were formerly occupied by forests, as is shown in some instances by the occurrence of the stumps of fir and other trees in the lower part of the deposits. Depending upon the situation in which the peat accumulations commence, the character of the final deposit varies between comparatively firm deposits, such as those of the Highlands of Scotland, to the treacherous bogs so characteristic of many parts of the lowlands of Ireland.

Peat deposits are widely distributed throughout the world. In Ireland it is estimated that the peat area is not less than one-seventh of the whole island. The Irish deposits are remarkable for their great depth, many reaching a depth of nearly 50 feet. The area occupied by peat in the United Kingdom is about six million acres, with an average depth of 12 feet. Assuming that one acre will yield 3,500 tons of dried peat, some idea of the vast stores of the crude material not yet touched in this country will be obtained. The German peat area is estimated to be about 30,000 sq. km. (more than 11,000 sq. miles), and the yield per sq. km. for a depth of 5 mètres (16 feet) is approximately 800,000 tons of air-dried peat. The peat

deposits of Scandinavia are estimated to contain a quantity whose fuel value is equal to that of 3,000 million tons of coal.

Composition of Peat.

Peat varies widely in composition, and the relative proportion of water and of ash-giving constituents, which are of no value as fuel, are so variable that it is almost impossible to state an average composition. The best air-dried peat still contains 25 per cent. of "hygroscopic water." From various analyses the composition of pure peat, exclusive of moisture, has been found to be as follows:—

Carbon	49·6 to 63·9 per cent.
Hydrogen	4·7 to 6·8 „
Oxygen	28·6 to 44·1 „
Nitrogen	0·0 to 2·6 „

The mean composition of good air-dried peat is approximately—

"Hygroscopic water"	25·0 per cent.
Water	28·5 „
Hydrogen	1·5 „
Carbon	45·0 „

The proportion of ash-giving constituents varies from 1 to 30 per cent. and is rarely below 10 per cent. It consists largely of lime, ferric oxide, alumina and sulphuric acid with smaller proportions of alkalis and phosphoric acid.

The calorific power of peat varies inversely as the amount of water and ash it contains. For peat without ash and water the calorific power is 5,237, whilst for ordinary air-dried peat it does not exceed 3,000 calories.

The specific gravity varies with the proportion of ash and the mode of preparation from 0·113 to 1·039.

Methods of Manufacture into Fuel.

In Europe three kinds of peat fuel are in use. These are (1) "cut peat," prepared by cutting the crude peat out of the bog in blocks and drying in the air; (2) "machine peat," procured by pulping the wet material, sometimes with the addition of

water, and then cutting or moulding into blocks and drying with or without artificial heat; and (3) "peat briquettes," made by artificially drying and compressing powdered peat.

"*Cut Peat.*"

In this class may be included nearly all the peat which has been extracted by the peasantry in European countries for generations past. The preparation of this class of fuel may be very varied according to the kind of peat used. The primitive method was simply to remove the green surface and dig out rectangular blocks from the bog. Where the peat was in the condition of mud, as in many Irish bogs, the mud was scooped out and spread over the bank to dry in the spring. When of sufficient hardness it was cut into blocks and these turned over and gradually dried, which process often took the whole summer. The blocks of peat dry down to a water content of about 30 per cent.

On a larger scale, when it is intended to work the whole bog as is done in continental countries, special attention should be paid to the early works, especially as regards draining, since errors in this direction cannot subsequently be made good. The following account given by Schacht indicates how this is done in some of the German peat deposits. In draining a very wet bog having a total depth of, say, 5 to 6 mètres (15 to 20 feet), it is usual to sink trial-holes in the line of the main drain, to ascertain to what depth trenches can be sunk without entailing the collapse of the sides. These trial trenches should be from 5 to 6 mètres in length, and from $\frac{3}{4}$ to 1 mètre in breadth. In a very wet bog a maximum depth for the main drain of $\frac{1}{2}$ mètre can only be obtained in the first year. During the second year the trench may be deepened to from $\frac{3}{4}$ to 1 mètre, and off-set trenches or headings at right angles to the main ditch should be driven at distances of three times the total depth of the bog to a distance of 9 or 10 mètres on either side of the main drain, and to such a depth as experience warrants, usually about 0·5 to 0·7 mètre.

The next year the trenches are excavated another $\frac{1}{2}$ mètre. If all goes well it becomes possible in the third year to deepen the drain to $1\frac{1}{2}$ mètres with a width of 1 mètre, and this done the

preparatory work is completed. The surrounding peat drains freely at the end of the third year. In order to provide an outlet for the more distant water endeavouring to find its way into the central drain, it is usual to cut parallel drains on either side of the main drain, and at a distance from it of 50 to 100 mètres; these drains should be 1 sq. mètre in section. In the fourth year the cutting of turf for sale may begin, and this can best be carried out in layers or "banquers" 3 mètres wide and $1\frac{1}{4}$ mètres deep. The total cost, where labour is worth 2 marks a day, is for the first three years' work 8 pfennig per cubic mètre; the subsequent cost of cutting the peat, apart from turning and drying, etc., may be in the fourth year 15 pfennig, and in the fifth year 20 pfennig, and in the sixth and following years 30 pfennig per cubic mètre ($2\frac{3}{4}$*d.* per cubic yard). This has reference entirely to hand work.

Machine Peat.

For making machine peat there are two principal processes, this classification depending upon the different treatments of the raw material immediately after raising it from the bog. One plan is to convert the peat by the addition of water into a liquid mud, which is then poured into moulds in the open air, and after losing some of its water it is divided into blocks and allowed to dry. The other and more generally-used process consists in grinding or mincing the peat as it comes from the bog into a soft plastic mass, which is then cut into bricks and dried. This latter process is known as "kneading the peat."

At Haarlem, in Holland, the peat beds are below the sea level, and vary in thickness from 5 feet to 6 feet 6 inches; the latter thickness yields only 800 tons per acre of air-dried peat, containing 25 per cent. of moisture. Here the peaty mud is scooped up by an elevator, consisting of a large iron lighter carrying a steam engine with scooping and kneading apparatus. Twelve such excavators, each turning out daily 100 to 200 tons of peat reckoned as air-dried, collectively produce 50,000 tons of air-dried peat per annum. The depth of water on which they float on the bog is a little over one foot. They deliver the kneaded peat to the drying floors at an all-round cost of 1.8 gulden (3*s.*) per ton. It is spread out in a layer 2 feet thick, which will dry

down to half its thickness in about two days. It is then cut up into blocks 3 inches square and 5½ inches long, which are stood on end. The quantity dried per acre is 400 tons of dry peat per annum. The peat is finally stacked and the stacks thatched.

Each excavator requires nine men. The cost of manufacture of machine peat, including delivery to the stores in Haarlem, is 9 gulden (15*s.*) per ton, and the selling price is 10 to 11 gulden (16*s.* 8*d.* to 18*s.* 4*d.*) wholesale, and from 12 to 16 gulden (20*s.* to 26*s.* 8*d.*) retail.

Intermediate in type between the "kneaded peat" and the briquettes (described subsequently) is the machine-made peat fuel used in Sweden, Denmark and Germany. For the preparation of this the peat is thoroughly mixed, ground up and then forced through an orifice of 5 to 8 square inches, whence it arrives in the form of a long pole or column, which is cut up into pieces of suitable length. After lying two to three weeks on the ground the pieces can be piled up together, and two or three weeks later they are dry enough to be stacked or shipped. Peat thus pressed weighs from 590 to 670 lbs. per cubic yard, and costs about 5*s.* 6*d.* per ton in Sweden, loaded into wagons at the bog, including all charges. The production of dry peat from four classes of machines working in Sweden is given in the following table, from an estimate by J. G. Thaulow (*Proc. Civ. Eng.*, Vol. cxlviii., p. 402).

PEAT FUEL MACHINES.

	Åkerman.	Anrep.	Munktell.	Åbjørn Andersson.
Engine power	18 h.p.	38 h.p.	20 h.p.	—
Number of men	15	28	17	—
Tons of dry peat produced per 10 hours	20–25	40–45	25–30	20–40
Cost of machine alone	£67	—	—	£40–£140
Total cost with all adjuncts, including engine, rails, wagons, etc.	£390	£830	£500	—

The Åkerman machine has been the longest and most extensively used in Sweden, and in its most improved form is stated to have given great satisfaction. It is driven by an independent portable engine. Estimates for larger plants are given in the *Trans. Amer. Inst. Min. Eng.* for May 1904, by R. Schorr.

Peat Briquettes.

During recent years the manufacture of compressed peat fuel has assumed importance in many European countries and also in Ontario, Canada, where the question of a regular supply of fuel at a reasonable price became very acute during the great Pennsylvania Coal Strike. Peat prepared by compression is denser and stronger than cut or kneaded peat, and can be more readily stored and transported. The manufacture in Canada, as described by Mr. W. E. H. Carter in Bull. No. 5 of the Bureau of Mines of Ontario, is similar in its preliminary operations to the procedure given under the working of bogs by hand. In a permanently wet bog, where the water does not admit of being drained away, as in the Trent Valley Bog, a dredge floating on the surface excavates the peat in trenches, and then floats into the paths thus cut for itself, with scows attending, each carrying a number of boxes of about 2 cubic yards capacity, into which the peat is loaded. The scows are towed to the terminus of an aërial tramway, over which the boxes are conveyed to the works (about 500 yards distant), where the saturated peat is dumped into the hopper of a root extractor and disintegrating machine, from which it issues sufficiently macerated for the drying process which follows. In another method used at the Newington Bog a Brosowski or Jasenitzer Peat Digger cuts out cubical blocks 3 feet by 1 foot by 1 foot.

In dry bogs, as in the Welland Bog, a system of ditching and draining is adopted. The growing or undecomposed moss is then removed together with protruding stumps and roots of trees, and a level surface is prepared for the digging or excavating process. A light tramway is laid down from the factory to the bog and may be carried into it also. At Beaverton the work of excavating is done by an electrically-driven digger, which travels up and down one or both sides of the area under removal, the excavating device working in the wall or side of the ditch. This machine, known as the Dobson Mechanical Excavator, consists of a platform 7 feet wide by 10 feet long, mounted on four wood-faced wheels, the front pair being the drivers and measuring 33 inches in diameter and 18 inches face.

The large superficial area of these wheels is necessitated by the softness of the bog surface. A 10 h.p. electric motor operates by belting and bearing all the machinery and at the same time propels the carriage. Overhanging the ditch on the right side is the combined excavating and elevating mechanism. It consists of an endless chain, which is set alternately with a row of cutting teeth and a sharp-edged plate. It serves the double purpose of scraping off a thin slice of peat and elevating it to a conveyor running across the front of the carriage. At the opposite side of the distributor a partially-hooded paddle-wheel, revolving at a high velocity, catches the stream of fragments and showers them over the surface of the bog to a distance of from 30 to 50 feet; when sufficiently dry the peat is raked together and conveyed by the tramway to the factory. The cost of attendance and power is estimated at \$2·256 per day, and the quantity of peat worked equivalent to 22 tons of finished peat containing 15 per cent. of water.

The total cost per ton of finished fuel up to this stage is as follows:—

	$
Ditching	0·0141
Clearing	0·0052
Track-laying	0·0070
Excavating and spreading	0·1025
Scraping and raking	0·1909
Loading and tramming in	0·0714
Total	\$0·3911

The air-dried peat from the stock pile now passes to the hopper of the "breaker" or disintegrating machine, where it is subjected to a fierce hail of blows in order to reduce the size of the fragments and destroy the minute plant-cells of the peat fibres. The machine consists of a circular cast-iron box encasing a horizontal shaft, from which project radial cast-iron rods, each about 1 foot in length. Through the ends of these and parallel to the shaft run iron rods, each suspending a row of knob-like cast-steel fingers, 4 inches long and free to swing about the rods. The shaft makes 40 revolutions per minute, and the steel fingers, flying out radially, dash the peat fragments against a semi-

circular "grizzly," set close beneath. Through the $\frac{1}{16}$-inch square spaces of this grating the peat drops as a mixture of fine particles and dust, damp to the touch. The cost of the process is about \$0·0663 per ton of finished fuel. From the bottom of the breaker a conveyor carries the disintegrated peat to the hopper of the dryer, into the cylinder of which a regular feed is maintained. The Dobson Dryer, which is the one used at the Beaverton Works, consists of a cylinder 30 feet long by 3 feet in diameter, made of $\frac{3}{8}$-inch sheet-iron plates and set with an inclination of 14 inches in its length. The cylinder rests on bearings in a brickwork casing and revolves by chain gear $1\frac{1}{2}$ revolutions per minute, at which rate a charge of peat will pass through in 20 minutes. The greatest heat is applied at the upper end, where the damp peat enters. The hot gases pass along the outside and then up through the cylinder.

The air-dried peat as it enters the dryer contains 34 per cent. or more moisture and leaves with only about 16 per cent. The dryer is capable of treating 12·5 tons per day.

The Simpson Heat Dryer consists of two parallel revolving cylinders 30 feet long, one above the other. The space between is occupied by a conveyor pan. The peat first passes through the lower cylinder, then through the intervening compartment and finally the upper cylinder. The upper cylinder makes three revolutions per minute and the lower one nine per minute.

The peat is now in a condition to be pressed into briquettes. The original apparatus was of the open-tube type, in which the peat is forced into the tube by a ram, working at a pressure of about 8 tons to the square inch. The friction of the peat against the sides is very great, and the length of the tube is so adapted that pressure does not increase much above 8 tons to the square inch. The heat developed appears to induce chemical change and causes tarry matter to exude, which protects the briquette from the disintegrating effect of a damp atmosphere. The cost of the process amounted to \$0·2171 per ton of finished fuel. The wear of the machine is, however, excessive, and for this reason it has not come into general use. The Dobson Press consists of a number of dies resting on a solid base, which are rotated beneath a ram. The dies being filled with peat powder, the ram compresses it into briquettes of $2\frac{1}{4}$ inches diameter, 25 of which weigh 10 lbs.

The output of the press in 10 hours is $12\frac{1}{2}$ tons of finished fuel at a cost of \$0·1112 per ton.

The total cost of making briquettes at Beaverton is \$1·0096 per ton and at Welland \$0·9705 per ton. Taking into account the cost of the bog, interest on capital, royalty and depreciation of the plant, the total cost is stated to be about \$1.8 per ton. The price of the Beaverton product at the factory in 1901 was \$3 per ton, in 1902, \$3.75 per ton. The cost of the Dickson Briquetting Press is \$1,500 and the Simpson Dryer \$1,500, or including cost of setting up, \$1,750.

Peat Charcoal.

The object of carbonising peat is to get rid of that portion which has no calorific value, and to produce a charcoal which will compete with coal or coke. According to J. J. Tylvad (*Trans. Civ. Eng.*, Vol. clii., p. 369), one of the greatest difficulties in coking peat is the spontaneous ignition of peat charcoal at a low temperature. The best plan is to employ for coking the gas driven off from the peat itself. At Oldenburg, in Germany, this plan has been carried out by Ziegler. The operation is so conducted that the yield of peat charcoal is 35 per cent. with 4 per cent. of tar, and more gas is given off than is needed for firing. The Ziegler ovens are upright and their horizontal section is a flattened oval or D shape; they are arranged in pairs with their flat sides facing each other. Their curved backs are surrounded with flues, and the space between them also serves as a flue. The lower half of every oven or retort is constructed of refractory brick and the upper of cast iron. The products of distillation are exhausted through an air-condenser, in which the tar and water are separated; the impure gas, containing about 25 per cent. of carbon dioxide, is led back direct, without passing through any gasholder, into the flues surrounding the ovens, where it is burnt and thence discharged to the chimney.

Air admitted beneath the oven cools the bottom portion containing hot charcoal; it is thereby heated in readiness for burning at the place where the gas is admitted into the flues, about half way up. The charcoal is emptied into iron trucks, which are covered up, air-tight and left to cool out of doors.

The tar water contains in solution acetic acid, ammonia and

methyl alcohol. The tar obtained differs in composition from that obtained from wood or coal, and at ordinary temperatures is practically solid. After being mixed with sulphuric acid and washed it is distilled in cast-iron retorts, and yields 35 per cent. of crude oils, and 55 per cent. of crude paraffin scale ; the residue is loss and coke. According to Dr. Wolff, the gas contains 15 per cent. of methane and 24 per cent. of hydrogen.

OTHER USES OF PEAT.

The Manufacture of Textile Fibres.

The material used for the preparation of peat fibre is the layer lying between the living vegetation, which usually covers the surface of peat moors, and the true black turf which is used as fuel. This upper layer is employed for the preparation of litter and similar absorbent products, and for this purpose it is advantageous to remove the fibrous portion. It was at first somewhat difficult to find a method of utilising this fibrous product, but about 1880 an outlet was found for it in the manufacture of paper.

A few years later it was observed that this fibre could be readily cleaned and bleached, and that the material so prepared could be spun into yarn. Since then the preparation of peat fibre for textile purposes has received much attention, especially in Austria, Sweden, Holland and Germany.

The crude fibre is extracted from the peat either by means of disintegrating machines provided with oblique cutting surfaces, which stretch the fibre and cause the adherent pulverulent material to fall away, or by drums provided with teeth to separate the fibres by tearing, or the peat is thrown into water and broken up by a mechanical agitator when the fibrous matter floats to the top and is separated and dried.

The crude fibre is then treated with dilute alkali to remove adherent acid and gum-like products, the excess of alkali being eventually removed by treatment with dilute acid. The fibre is eventually carded and bleached with sulphur dioxide, chlorine, or a solution of sodium or calcium hypochlorite.

The product so obtained is composed of fibres of varying fineness and quality, and for special purposes the best material

is separated by a combination of beaters and fans, by which means the fibres are blown into a series of chambers and deposited according to their degree of fineness, the finest "down-like" fibres being carried into the chambers most remote from the fan.

The material so prepared may be spun into yarn, but it is usually first mixed with from 6 to 25 per cent. of wool or cotton, the former being the more generally employed.

Application of Peat Fibre.

At first peat fibre was solely employed for the manufacture of paper, but the discovery that it could be spun led to its use, mixed with wool, in the manufacture of coarse fabrics, such as horse cloths, army blankets, saddlecloths, carpets, mats or chair covers, whilst its aseptic and absorbent properties led to its application in surgical dressings and as a packing material. More recently the finer kinds of peat fibre have been used in conjunction with wool for the manufacture of fabrics suitable for underwear.

It is impossible to say to what extent peat fibre is employed at present as a textile material, but the amount produced is probably considerable, since large factories for the manufacture of peat fabrics exist at Paris, Admont in Austria, Weort in Holland, Oldenburg in Germany, and in Stigen (Sweden).

Peat fibre does not appear to be made in Great Britain, although it is stated that an attempt was made to manufacture the product in Yorkshire a few years ago. At present litter and similar materials appear to be the only products other than fuel made from peat in this country.

PRODUCTION OF WOOL IN BRITISH COLONIES.

ALTHOUGH during recent years the place of wool as a raw material for the manufacture of textiles has been taken by cotton and other materials to a considerable extent, yet the present supply, especially for the finer kinds of wool, is unequal to the demand for this material in trade. The failure of the

supply of raw wool appears to be due to several causes, but the most important of these is the change in the breeds of sheep now maintained in Australia, New Zealand, and South America, where the production of wool has become, in some cases, of secondary importance as compared with the production of frozen mutton. The breeds of sheep yielding the better qualities of mutton are those which furnish comparatively coarse and therefore inferior wools, and consequently in the competition of these two branches of trade the less remunerative, viz., the production of wool, has suffered.

In these circumstances it has been considered advisable to publish here a *résumé* of the present state of wool production in British Colonies, with such information as is available regarding the causes which have been operative in producing the present shortage. It appears that the deficiency noticed in previous years has become still more accentuated this year, and it is probable that the production of wool at the prices now prevailing would be highly remunerative in the Colonies.

Wool owes its peculiar utility to the possession of a number of properties not exhibited by cotton, silk or any other textile material. These properties are due partly to the composition and partly to the ultimate structure of the fibre.

The natural covering of the sheep in the wild state consists (1) of a short soft fibre, which forms the non-conducting coat serving principally to retain the heat of the body, and (2) of a growth of coarse hair, which acts as a protection against climatic changes.

An ideal wool for textile purposes would consist of the inner coat of fine hairs only, and consequently in the breeding of sheep, for wool production, attention is principally paid to the encouragement of the growth of the fine inner coat.

The principal factor in the successful production of fine wool is the preservation of the sheep from exposure to cold and damp and the provision of suitable food. For this reason the better qualities of wool can only be produced in large quantities in countries possessing equable and temperately warm climates. By the provision of a suitable environment a marked change in the character of the wool can be induced, thus the "Argali" sheep of Siberia, which in the wild state produces a growth of

downy soft white wool under a covering of coarse hair, when domesticated in a milder climate than that of Siberia produces a greater crop of fine wool and a smaller quantity of coarse hair.

The importance of the influence of environment may be indicated by the results of the trials made to produce "Mohair" in Australia. For some time after the introduction of the mohair goat the hair produced remained of satisfactory length, but it gradually deteriorated, finally approaching in length the "Merino" or short wool, which is produced to the greatest advantage in Australia.

Sheep's wool is usually white, though it may occur in natural colours of grey, brown and black. The character of the wool, as already indicated, depends to some extent on the environment in which the animal producing it has been grown, but is also to a greater extent dependent on the "race" of the animal; thus, an English Lincoln sheep produces long wool, whilst an Australian "Merino" produces short wool.

In the fine curly wools produced by the best types of Merino sheep each fibre possesses a serrated surface, and in the subsequent processes of manufacture the projecting scales of different fibres interlock with each other, so that the wool "felts" easily, as it is technically termed. In such wool the fibres may become so entangled as to be inseparable except by cutting.

Varieties of Wool.

There are three important varieties of wool commonly produced—

(1) Long—"English" or "Lustre" wool.

(2) Short—"Botany" or "Merino" wool (also English Down wool).

(3) Medium—"Crossbred" wool.

The description "English" is applied to the long wools produced by Lincolns and other similar breeds of sheep. This is a lustrous wool of good strength, from six to ten inches long, with a diameter of about $\frac{1}{600}$ inch. It is white and silky and of a good colour. Owing to the scale structure being only slightly developed "English" wool does not possess the felting property referred to above.

"Australian Merino" ("Botany") wool may be considered as

a typical felting wool. Owing to the scale structure being well developed, this variety has not the lustrous, silky appearance of the English wool. It is short, having a length of from one to three inches and a diameter of about $\frac{1}{2000}$ inch, and is extremely soft and fine. The best "Merino" is capable of being spun into very fine yarn, and is the most valuable wool produced.

"Cross-bred" wool is produced by cross-breeding "Lincoln" and "Merino," or short-wool sheep. In some cases "Cross-bred" wool has most of the properties of the "Merino," that is, it is short and curly, non-lustrous and a good felting wool; in other cases it more nearly approaches the long "English" wool.

COLONIAL WOOL.

Australia.

The finest and most expensive varieties of wool are successfully grown in Australia.

Victoria. Port Philip "Merino" sheep are direct descendants of the original Spanish Merino. The wool produced by this type of sheep is soft and fine, about one to two inches in length, very much waved and possessing well-marked felting properties.

The Port Philip "Cross-bred" wool is produced by sheep which are cross-breeds between "Merino" and "English" long-wool sheep. This wool is in much demand as a fine "cross-bred," and is good of its type. Other types of pure "Merino" and "Cross-bred" similar to the above, but more or less inferior in quality, are grown in New South Wales, Queensland, South Australia, West Australia (Swan River), and Tasmania. Australia is essentially a "Merino" country, and in order to produce "cross-bred" wool it is necessary to introduce continually such types of long-wool sheep as the Lincoln, Leicester, etc., as the "cross-bred" sheep alone quickly reverts to the "Merino" type.

New Zealand.

Pure "Merino" is grown in New Zealand, although not to such perfection as in Australia. Varieties of "cross-breds" also thrive, and although not always equal to the Australian "cross-bred," they are in great demand, and are used for similar purposes. Experiments are being carried out by the Department

of Agriculture in the breeding of Angora goats for mohair, but the results of these experiments have not yet been made public.

South African Colonies.

The wool grown in these colonies is chiefly of the "Merino" type—short and soft. It is inferior to the Australian "Merino," chiefly, it is said, on account of inferior breeding; but the absence of good pasture land and the sandy nature of the soil also exert a deteriorating influence on the wool produced.

The type in greatest demand is the Natal wool, this being cleaner and better cared for during its growth.

Mohair is largely grown in Cape Colony, but it is somewhat inferior to Turkish mohair. With increased care in breeding and by the constant introduction of new blood, the Cape mohair will probably prove a formidable rival to the Turkish variety in the near future.

East Indies.

The type of wool produced in the East Indies is known as carpet wool; it is a strong, coarse variety, suitable for making carpets and other similar materials.

Falkland Islands.

A type of Scotch sheep is bred on these Islands, producing a rough Cheviot variety of wool.

Canada.

The climate of this Colony favours a type of long-wool sheep, similar to the English. The wool produced is of good length but somewhat lacking in lustre. "Cross-bred" wool is also produced.

Increase in Production of "Cross-bred" Wool.

The growth of the frozen meat trade in New Zealand and South America is primarily responsible for the enormous proportion of the coarser "cross-bred" wools now produced, since for the purposes of this trade cross-breeds of sheep are better than the pure types.

In 1895, 70 per cent. of the wool produced in New Zealand and South America was "Merino" and the remainder "Cross-

bred." To-day the proportion of the latter has increased to 50 per cent. of the whole. With the same quantity of the "greasy" wool this would mean an increase in the total production of clean wool, because New Zealand and South American "Cross-bred" will yield approximately 70 to 85 per cent. of clean wool, whereas "greasy Merino" will yield only 40 to 70 per cent. of clean wool.

In a paper communicated to the Textile Society of the Bradford Technical College in January 1905, Mr. A. R. Byles stated that for some years prior to 1895 the world's production of wool had been steadily increasing. In 1885 it was 1,600,000, in 1890, 2,000,000, and in 1895, 2,750,000 bales. Then began a steady decline. In 1900 it stood at 2,000,000 bales, and this year (1905) it would probably be from 1,500,000 to 1,750,000 bales below the quantity which might have been expected if the rate of increase prior to 1895 had been maintained.

Ten years ago 396,000,000 lb. of clean scoured "Merino" were available. Last year there were only 244,000,000 lb., and if it had not been for the increase in the production of "Cross-bred" the position would have been serious.

In Australia, as a result of the severe drought in 1901-02, affecting our supply in 1903, there was a decrease in the output of "Merino" of 250,000 bales,* while the supplies of "Cross-bred" wools were well maintained.

During the past twelve months, however, not only has the world's production of "Merino" again fallen off considerably, but the output of "Cross-bred" has also been reduced by the equivalent of some 200,000 bales of Colonial wool, through deficient clips in Argentine, New Zealand, North America and Great Britain.

For the present year the prospects were at first believed to be somewhat better, and it was thought that increased quantities of both "Merino" and "Cross-bred" wools would be available, but up to the present these expectations have by no means been realised.

* These figures are from the *Colonial Wool Circular* of Messrs. Balme & Co., London.

World's Wool Production (1903).

The following table is taken from *Statistics Relating to the Woollen and Worsted Trades of the United Kingdom*, compiled by Mr. F. Hooper, Secretary of the Bradford Chamber of Commerce :—

	lb.	lb.
Europe—		
Great Britain and Ireland	133,000,000	
Russia (including Poland)	361,000,000	
France	103,500,000	
Spain	102,500,000	
Germany	49,500,000	
Austria-Hungary	64,000,000	
Italy	21,500,000	
Portugal	13,500,000	
Sweden and Norway	8,000,000	
Turkey and Balkan Peninsular	67,500,000	
All other Europe	14,000,000	938,000,000
North America—		
United States	287,500,000	
British North America	12,000,000	
Mexico	5,000,000	304,500,000
South America—		
Argentine Republic	370,000,000	
Chile	7,500,000	
Brazil	1,500,000	
Uruguay	96,000,000	
Venezuela	15,000,000	
All other	20,000,000	510,000,000
Central America and West Indies	....	5,000,000
Asia—		
Russia	60,000,000	
British India	85,000,000	
Asiatic Turkey	33,000,000	
Central Asia	46,000,000	
China	35,000,000	
All other Asia	15,000,000	274,000,000
Australasia	....	500,000,000
Africa—		
Algeria and Tunis	30,450,000	
Egypt	3,000,000	
British South Africa	100,000,000	
All other Africa	1,000,000	134,450,000
Oceanica	....	50,000
Total	....	2,666,000,000

The quantity of wool of domestic production exported from the principal British Possessions during the five years ending 1903 is shown in the following table, taken from the *Statistical Abstract for the Several British Colonies and Possessions* for 1903 [Cd. 1912 of 1904]:—

TOTAL EXPORTS OF WOOL FROM THE COLONIES.

Possessions.	1899.	1900.	1901.	1902.	1903
	lb.	lb.	lb.	lb.	lb.
British India (*a*) . .	31,935,412	21,873,859	19,592,620	27,892,898	33,241,030
Exports by sea—					
Australia (*b*) . . .	391,130,357	335,395,181	451,445,729	335,861,425	325,600,593
New Zealand . . .	147,169,497	140,706,486	146,820,079	160,419,023	155,128,381
Falkland Islands . .	4,823,458	4,341,180	4,373,340	4,360,260	4,023,807
Natal (*d*).	20,435,499	2,522,341	10,852,088	9,482,018	10,991,359
Cape of Good Hope (*d*)	69,289,606	27,671,036	65,209,699	79,327,850	65,524,078
Dominion of Canada (*c*)	90,038	2,181,047	1,043,673	1,972,772	2,527,150
Total	664,873,867	534,691,130	699,337,228	619,316,246	597,036,398

(*a*) For the twelve months ended 31st of March of the years following those stated.
(*b*) These figures show for each year the excess of wool exported from Australia to non-Australian countries over imports thereof from such countries.
(*c*) For the years ended 30th June.
(*d*) The figures given represent the exports of wool, the produce of South Africa (*i. e.* including Transvaal and Orange River Colony, etc.).

The total exports of wool from the principal British Possessions to the United Kingdom during the same period, 1899–1903, are as follows:—

EXPORTS OF WOOL (DOMESTIC PRODUCE) FROM THE COLONIES TO THE UNITED KINGDOM.

Possessions.	1899.	1900.	1901.	1902.	1903.
	lb.	lb.	lb.	lb.	lb.
British India—					
Exports by sea (*a*).	31,404,158	21,405,739	18,557,207	27,431,902	32,364,903
Australia (*c*)—					
New South Wales.	83,149,620	98,740,434	113,707,685	79,516,949	62,099,933
Victoria	64,241,016	72,625,314	83,413,057	57,745,611	37,634,788
South Australia .	35,722,712	33,582,180	33,911,214	29,065,452	30,176,418
,, ,, (N. Territory) . .	—	—	—	—	—
Western Australia.	9,748,979	8,925,869	13,418,319	12,835,651	12,565,623
Queensland . . .	31,202,791	27,833,494	31,599,892	16,947,065	19,711,247
Tasmania . . .	5,319,619	4,734,559	7,797,582	6,533,086	4,881,483
Total Commonw'lth (*c*)	229,384,737	246,441,850	283,847,749	202,643,814	167,069,492(*e*)
New Zealand . . .	145,782,594	139,683,129	146,612,713	159,638,237	153,904,612
Falkland Islands . .	4,823,458	4,341,180	4,373,337	4,360,260	4,023,807
Natal (*d*)	19,228,422	2,425,302	6,117,142	4,838,506	5,222,142
Cape of Good Hope (*d*)	68,053,180	26,901,553	61,230,079	72,471,190	61,682,612
Dominion of Canada (*b*)	59,394	241,062	93,300	81,963	235,178
Total	498,735,943	441,439,815	520,831,527	471,465,872	424,502,746

(*a*) For the twelve months ended 31st March of the years following those stated.
(*b*) For the years ended 30th June.
(*c*) The figures given for each of the Australian States represent *total* exports of wool (*i.e.* domestic and foreign) to the United Kingdom.
(*d*) The figures given represent the exports to the United Kingdom of wool, the produce of South Africa (*i.e.* including Transvaal and Orange River Colony, etc.).
(*e*) According to the returns of the several States of the Commonwealth. In 1903, however, the Commonwealth Government issued the Customs Returns for the first time, and according to these returns the exports of Australian wool to the United Kingdom were 170,684,932 lb. in 1903.

WOOL SUPPLY OF THE UNITED KINGDOM (including Sheep, Lamb, Alpaca, and the Llama Tribe) in thousands of lb.

Origin.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Foreign Countries	82,836	86,292	115,333	101,642	127,263	114,556	109,301	104,742	119,180	117,901	112,509
British Possessions	595,111	619,176	660,046	616,895	613,486	584,999	559,516	454,209	573,194	525,397	492,452
Total Imported	677,947	705,468	775,379	718,537	740,749	669,555	668,817	558,951	692,374	643,298	604,961
Home Grown *	150,612	141,509	135,395	136,287	138,657	138,392	140,232	141,146	138,484	135,684	133,125
Re-exported (Foreign and Colonial)	346,369	345,927	404,935	334,692	371,503	283,318	292,937	196,207	294,214	285,372	285,499
Exported (Home Grown) *	16,160	12,998	21,717	18,039	40,103	12,284	22,645	24,934	20,232	36,280	35,932
Excess of Imports (Foreign and Colonial)	331,578	359,541	370,443	383,845	369,426	416,237	375,880	362,743	398,160	357,926	319,462
Excess of Home Production *	134,452	128,511	113,678	118,248	98,554	126,108	117,587	116,212	118,252	99,404	97,193
Total for Home Consumption	466,030	488,052	484,121	502,073	467,980	542,345	493,467	478,955	516,412	457,330	416,655

The above figures are from the *Statistical Abstract for the United Kingdom* [Cd. 2192 of 1904] except those marked * which are from the *Yorkshire Daily Observer* Wool Tables, 1904.

PRODUCTION OF WOOL IN THE UNITED KINGDOM.

	1899.	1900.	1901.	1902.	1903.	1904.
	lb.	lb.	lb.	lb.	lb.	lb.
Production . .	140,232,392	141,146,376	138,483,539	135,684,178	133,124,762	131,963,686
Exportation . .	22,645,000	24,934,000	20,232,000	36,280,000	35,931,800	37,860,000
Left for Home Consumption .	117,587,392	116,212,376	118,251,539	99,404,178	97,192,962	94,103,686

The above figures are taken from the *Yorkshire Daily Observer* Wool Tables.

INDUSTRIAL APPLICATIONS OF UNORGANISED FERMENTS.

THE term "fermentation" is now generally applied in such a way as to include all chemical changes, either inorganic or organic, which are induced by certain organic substances derived directly from the animal or vegetable kingdom. These substances are known as ferments, and themselves appear to undergo no change in condition as the result of the action.

Of these ferments, some have an organised structure, and are capable of independent development and multiplication—are, in fact, isolated organisms; the remainder possess all the essential characteristics of chemical compounds. They are incapable of separate growth, and can be dissolved and reprecipitated unchanged from solutions. This latter class comprises the unorganised or soluble ferments, or, as they are more generally designated, enzymes. Many of these play an important part, and find widespread application in the arts.

The line between these two classes of ferments is not a sharp one, although until a few years back they were strictly divided. Thus it was considered that the action of the organised ferments could not be dissociated from the living cell. Buchner, however, obtained in 1899 a soluble ferment from yeast quite apart from the organism itself, but possessing the same property of causing alcoholic fermentation of sugar.

In a great many cases of fermentation hitherto attributed to micro-organisms it has recently been shown that the action is

due to enzymes secreted or excreted by them, no real fermentative power being directly due to the cell itself. Examples of this in the case of the fission-fungi are the so-called acetic and lactic acid fermentations, which will be considered more fully later on. Buchner has recently shown that from the bacteria causing these fermentations, extracts can be made by means of acetone, which, although containing no living cells, have the same action as the organisms themselves. From this the presence of enzymes which cause the decomposition must be inferred. Very possibly all the fermentation processes induced by the various kinds of bacteria and moulds will eventually be traced to such a cause.

In this article only such industrial fermentations will be considered as are caused directly by enzymes, or proved to be due to enzymes, though primarily of microbic origin. The treatment of the technical uses of the micro-organisms is a much broader subject, and comprises the science of mycology as applied to the industries.

The enzymes can be divided, according to their chemical action, into two main classes—those which act hydrolytically in a similar manner to dilute acids or alkalis, and those whose action is oxydative.

The principal hydrolysing enzymes are the following :—

(*a*) Those causing the decomposition of the carbo-hydrates. The best examples are the splitting up of starch into sugars by the diastases, the inversion of cane-sugar by invertase and the degradation of cellulose by cytase.

(*b*) The glucosidolytic enzymes. This includes a large number of enzymes with specific action, such as emulsin, which splits up amygdalin into glucose, prussic acid and benzaldehyde.

(*c*) Those which cause the degradation of the albumens, acting digestively like pepsin and trypsin, or in the manner of the lab-ferments contained in rennet, which coagulate casein to paracasein.

(*d*) The fat-splitting enzymes or lipases, which decompose esters, including oils and fats.

(*e*) The lactic acid ferments.

The second class, the oxydases, need not for the present purposes be sub-divided.

One action which cannot be placed in either of the above divisions and yet has several characteristics of both, is the alcoholic fermentation of sugar by means of zymase, which has been mentioned already.

Distilling, Brewing and Vinification.

The initial processes involved in the manufacture of spirit are identical at least in principle with those of beer-making. In both cases matter rich in starch is converted by means of the enzyme diastase into fermentable sugars. This is the action which takes place in the conversion of barley into malt, the barley containing starch which is converted by the enzyme, diastase, also present in the barley, into dextrin and the fermentable sugar maltose, which is then by the action of the enzymes in the yeast broken down into alcohol and carbon dioxide.

If the alcohol is required for industrial purposes, potatoes made into a mash by steaming are used as the source of starch, the employment of farinaceous grains being limited to the production of spirits for drinking. In the former case the conversion of the starch or similar raw product into fermentable sugars is brought about by hydrolysis with sulphuric acid, and this process has also largely supplanted the diastatic conversion of starch involved in "malting" in the process of beer-making, glucose prepared from maize starch by hydrolysis with sulphuric acid being now largely used for the production of beer.

It has been found that in the first process involving diastatic fermentation, temperature has a large influence on the reaction, for whereas at high temperatures there is a preponderance of dextrin, at lower temperatures more sugar is produced. This fact has been used as an argument for the presence of two distinct enzymes in malt diastase. It is here also that the first real difference occurs between brewing and distilling, the brewer not desiring to convert all his extractive matter into alcohol. The distiller, on the other hand, wishes to convert as much as possible of his material into spirit, and he consequently produces a wort containing a minimum of dextrinous matter, this being best accomplished by working at a temperature of 50°–60°.

Sugar and molasses are also sometimes used as raw materials

for spirit manufacture, in which case they are fermented by yeast straight away. In this way the soluble ferment invertase, secreted by the yeast cells, breaks down the more complex sugars into simpler materials of the glucose type, which are thereupon fermented as before.

Souring of Distillery Mash.

In distillery work yet another enzyme comes into consideration before fermentation may be induced in the wort, its action occurring during the production of the "pitching" yeast. In the sister industry of brewing there is no necessity for preparing this "artificial" yeast, as the wort being thin allows the yeast to settle down to the bottom of the tun when the fermentation is at an end. It can then be used for pitching a fresh quantity of wort.

Before proceeding with the description of its specific action, it will be necessary here to give a short general explanation of the enzyme used in the acidification of yeast mash, it being the one secreted by the so-called lactic acid bacteria which play a considerable part in many industrial processes.

The chemical change involved in lactic fermentation is generally expressed as follows:—

$$\underset{\textit{lactose}}{C_{12}H_{22}O_{11}} + H_2O = 4\,\underset{\textit{lactic acid}}{C_3H_6O_3}$$

$$\underset{\textit{dextrose}}{C_6H_{12}O_6} = 2\,\underset{\textit{lactic acid}}{C_3H_6O_3}$$

As a matter of fact, when the bacteria themselves are used, the action is much more complicated, quantities of the sugar being consumed by them in the discharge of their vital functions.

Recently, Buchner and Meisenheimer have isolated the enzyme which causes the above decomposition, the bacterial cells being killed with acetone without destroying the enzyme. For their experiments in this direction pure cultures of *Bacillus Delbrückii* from souring distillery mash were employed.

In the growing of pitching yeast for distillery work, a sweet mash consisting principally of crushed green malt is allowed to saccharify. Before this medium is pitched with the yeast to be reproduced, it has to be subjected to the "souring" process.

The malt contains a number of bacteria, many of which produce butyric acid which acts as a poison to the yeast and must therefore be eliminated. For this purpose the butyric bacteria are killed by means of lactic acid produced by the enzyme of the lactic bacteria, the former being very sensitive towards a high degree of acidity. Hitherto this acidification has been left more or less to chance, the temperature merely being kept at 47°–52°, the optimum temperature of lactic fermentation. Lately, however, experiments on the artificial inoculation of the yeast mash with pure bacterial cultures have proved very successful, and the application of this method is being considerably extended.

The Fermentation of the Wort.

Before the researches of Buchner, many theories were advanced to explain the fermentation of sugar by yeast, Pasteur's theory that the presence of the yeast plant itself is essential to alcoholic fermentation being the one most generally accepted. About eight years ago, however, Buchner showed that by grinding yeast with quartz sand and kieselguhr in order to burst the cells, and then subjecting the mass to high pressure, a liquid can be obtained which, although containing no living cells, causes the fermentation of sugar almost as readily as yeast itself.

The action is not therefore vitally bound up with the life or death of the yeast organisms, but is due to a soluble unorganized ferment, an active preparation of which can be obtained by precipitation with alcohol, and to which Buchner gave the name zymase.

Zymase is one of the most sensitive of the soluble ferments and the generic name of enzyme cannot strictly be applied to it, and many chemists regard it as possessing a structure allied to that of living protoplasm.

Of the maladies to which spirituous liquors are subject, the lactic acidification of wine and the "turning" of beer are due to undesirable lactic fermentation. In other cases, however, as in the preparation of white beer and also of ginger beer, a vigorous lactic fermentation is regarded favourably and its development encouraged.

Manufacture of Vinegar.

Vinegar, of which the active constituent is acetic acid, is produced by the action of oxygen on alcoholic liquids, under the influence of ferments. This action, as previously stated, has been shown by Buchner in a similar manner to the lactic fermentation, to be due to an enzyme, and as the formation of acetic acid from alcohol is an oxydation process, the enzyme would appear to be a kind of oxydase. In his experiments, Buchner used the bacterium of beer vinegar. In the manufacture of this vinegar, a fermented infusion of malt is acetified in large casks kept at 24° and through which air can readily circulate. The fermentation generally requires about three months to bring to a conclusion.

The Essential Oils.

Of the volatile oils of vegetable origin which have a commercial value on account of their medicinal value or agreeable taste or smell, several are not pre-existent in the plant as such, but in the form of glucosides, which under the influence of enzymes, are hydrolysed, in the same manner as by dilute mineral acids, with the production of the volatile oil and simultaneous formation of grape sugar. The principal essences owing their production to such decompositions are the mustard oils, oil of bitter almonds and oil of wintergreen.

Mustard oil is prepared by the action of tepid water on dry mustard seed from which the fatty oil has been removed by pressure. Fermentation is thus brought about by the enzyme myrosin, which acts on the glucoside sinigrin (potassium myronate) with the formation of mustard oil, dextrose and acid potassium sulphate. The oil is then distilled in a current of steam.

$$\underset{\textit{sinigrin}}{C_{10}H_{16}NS_2KO_9} + H_2O = \underset{\textit{allyl mustard oil}}{CSNC_3H_5} + \underset{\textit{dextrose}}{C_6H_{12}O_6} + KHSO_4$$

The sinigrin is present in black mustard seed but not in white, which contains a different glucoside, sinalbin, from which, by the action of myrosin, sinalbin mustard oil is produced, dextrose and sinapine sulphate resulting as by-products.

$$\underset{\textit{sinalbin}}{C_{30}H_{42}N_2S_2O_{15}} + H_2O = \underset{\textit{sinalbin mustard oil}}{C_7H_7ONCS} + C_6H_{12}O_6 + \underset{\textit{sinapine sulphate}}{C_{16}H_{24}N_2O_5HSO_4}$$

The mustard oils are employed medicinally as rubefacients and nervous stimulants; these effects are followed by insensibility in the part affected and consequent relief from pain.

Oil of bitter almonds, which is now generally prepared from the seeds of the apricot when it is not of artificial origin, is not present as such in the seeds, but is formed by a process of enzyme action similar to that producing mustard oil. In the presence of water the glucoside amygdalin which is present in the seeds is hydrolysed by an enzyme known as emulsin, into benzaldehyde, prussic acid, and dextrose according to the equation:

$$\underset{\text{amygdalin}}{C_{20}H_{27}NO_{11}} + 2H_2O = \underset{\text{benzaldehyde}}{C_6H_5CHO} + \underset{\text{prussic acid}}{HCN} + 2C_6H_{12}O_6$$

The fermentation must be completed before the distillation is begun, as the emulsin is destroyed at temperatures much above 70°. Consequently the action is allowed to continue for twelve hours before the oil is removed by distillation with water vapour.

Wintergreen oil, obtained from *Gaultheria procumbens* or from the sweet birch bark, is prepared in large quantities for use as an "aromatic" for cosmetics, pharmaceutical preparations, medicinal and refreshing beverages, etc., and is a valuable article of commerce. Its chief chemical constituent is methyl salicylate, which results from the interaction of two constituents of the bark in presence of water. These substances are the glucoside gaultherin and its specific enzyme gaultherase or betulase. The only other product of the reaction is the usual grape sugar.

$$\underset{\text{gaultherin}}{C_{14}H_{18}O_8} + H_2O = \underset{\text{methyl salicylate}}{C_6H_4\begin{cases} OH \\ COOCH_3 \end{cases}} + C_6H_{12}O_6$$

Vegetable Colouring Matters.

A large number of natural dyes owe their formation to the decomposition of glucosides, and in many cases this is effected by hydrolysis with soluble ferments. Examples of this are the formation of indigo from indican, alizarin from ruberythric acid, occurring in madder, purpurin from a similar glucoside and rhamnetin from xanthorhamnin. Of these, the only two of any importance is indigo, as natural alizarin is no longer an

article of commerce since its synthetical production from anthracene in 1869. The ferment erythrozyme which causes the decomposition of ruberythric acid is co-existent with the glucoside in the plant cells and is distinct from emulsin, as it has no action on amygdalin.

Until quite recently, it was commonly supposed that the fermentation of the glucoside indican to indigo-blue and indiglucin was effected by microbes. It has been conclusively proved by Bréaudat, however, that the action is not microbic but enzymic in character, and he suggests the successive action of a hydrolytic (glucosidolytic) ferment which splits up the indican to indigo white and indiglucin, and an oxydase which oxidises the indigo white to indigotin.

For the preparation of the dye-stuff, the young plants are merely submerged in water and allowed to soak for 9–15 hours, according to the temperature of the atmosphere. Fermentation quickly ensues, and when it has ceased, the yellow supernatant liquid is run off and agitated until all the indigo is precipitated as a fine powder, which is allowed to settle, and the muddy sediment collected.

Cheese and Butter Making.

Milk intended for the preparation of cheese can be curdled in two ways. The first is by acidification, the acid being generated by fermentation, whereby the principal nitrogenous constituent of milk, casein, is liberated from its calcium salt and precipitated as the so-called acid curd.

The other method of curdling is by lab or rennet, an enzyme secreted by certain glands in the stomach of the calf, from which it is prepared by drying and then digesting with a 5 per cent. salt solution. Lukewarm milk to which rennet is added gradually coagulates and forms, not casein, but a derivative of it known as paracasein. At the same time small quantities of lacto-protein are formed, which being soluble, remains in the whey. The coagulum of paracasein is known after pressing as rennet curd or crude cheese.

The decomposing power of rennet is very high, one part being sufficient to precipitate one hundred million parts of paracasein

The optimum temperature of the action lies at 37°, the coagulation requiring three times as long at 25°.

Rennet for cheese making is now prepared on a manufacturing scale, the products being rennet solution usually containing boric acid as a preservative, rennet powder, and rennet tabloids.

The crude cheese after pressing is set aside to undergo the spontaneous process of ripening, whereby it is converted into the more digestible and highly flavoured article of food. During the ripening of the pressed curd the paracasein is broken down, and in contrast to the uniformity of the fresh cheese which only contains the one nitrogenous compound, the finished product contains a large number, the chief of which are leucin, tyrosin, and other amido acids, together with bodies like caseo-glutin, an albuminoid of the peptone class.

From ripe cheese many different species of schizomycetes can be obtained, and these in nearly every case excrete two enzymes, which can be thrown down from the cultures by means of alcohol. Of these enzymes, one is a lab, and coagulates milk; the other, casease, is a proteolytic enzyme, which dissolves and breaks up the albumin thus precipitated. The products formed by this trypsin-like ferment, leucin, tyrosin, and ammonium salts, are identical with those which are produced during the ripening of cheese. The process of maturing would accordingly appear to be due to the digestive action of casease on the paracasein of the rennet curd.

Butter intended for consumption in the United Kingdom is prepared from cream which has been previously allowed to go sour. This acidification is principally due to lactic fermentation, and consequently, as previously explained, to the enzyme produced by lactic bacteria. Recently attempts have been made to introduce artificial souring by employing pure cultures of these organisms.

Lactic Fermentation in the Preparation of Fodder.

The preservation of green fodder as practised in the preparation of brown hay and in ensilage, depends in a large measure on the action of lactic bacteria, whereby the carbohydrates are partly converted into lactic acid.

For the preparation of brown hay the material must be stacked

in ricks about fifteen feet high, well trodden down, and thatched. After three to four days, spontaneous heating or "sweating" is observed, and this is allowed to continue for another fortnight, about eight weeks being necessary for the completion of the change. The product forms a dry mass with a sweet aromatic smell, and contains about 7 per cent. of lactic acid. The heating is due to thermogenic bacteria, the rick acquiring an average temperature of 40° to 50°, this being the temperature of greatest activity of the lactic bacteria. These permeate the whole mass, and their metabolic enzyme causes the decomposition on which the change depends.

In many cases where it is impossible to even partially dry the material, it is subjected to an acid fermentation without previous removal of water. This process of preparing durable fodder is termed ensilage, and is generally carried out in shallow pits.

According to the method of treatment, two different products are obtained, viz. "green pressed fodder" and "sour fodder," the chief factor determining which shall be formed being the temperature of fermentation.

The green fodder is produced almost exclusively by lactic organisms, the sour fodder when these act in conjunction with butyric bacteria.

The preparation of the well-known foodstuff, sauerkraut, is also generally ascribed to lactic fermentation.

Enzymes in Tanning.

Leather manufacture consists essentially in the action on prepared animal skins of an infusion of one of the vegetable products containing bodies of the class known as "tannins," which have the power of combining with the fibre of the skin with the production of leather.

The preparation of the raw hide for this process proceeds in several steps, most of which are fermentative in character, but of which very little is really known, the whole process being carried out in an empirical manner.

The first step in the preparation of the skin is the removal of the hair, which is generally accomplished by soaking for several days in milk of lime. In this way the inner mucous layer of the epidermis is disintegrated, and the hair can be scraped off.

The same result can be obtained by a regulated putrefaction, in which micro-organisms play the principal part, but whether directly or by means of excreted enzymes is unknown.

After the "unhairing," the excess of lime is removed by steeping in a fermenting infusion of pigeon or hen excrement, the operation being termed "bating." For the lightest leathers, dog excrement is substituted for that of fowls, and the process is then called "puering."

These processes are followed by the "drenching," which is also sometimes used instead of them, and consists in soaking the skins in a fermenting infusion of bran, of which small quantities of lactic and acetic acids, which combine with the lime to form soluble calcium salts, are the active constituents.

This treatment makes the skin soft and flaccid, and converts it into a form in which the tanning materials are easily assimilated.

Bating and Puering.—The researches of J. T. Wood have shown that the effects of these processes are due to products of bacterial action, and that the fermentation is caused by enzymes produced by the bacteria. Certain amines, formed during the enzymic decomposition, also take part in the action.

Action due to proteolytic ferments is probably very limited in extent, the process, according to Wood's experiments, being most likely a hydrolytic one; it is certain nevertheless that a fresh puer contains proteolytic enzymes, capable of liquefying gelatine.

As a result of his investigations, Wood has prepared an artificial puer, now manufactured under the name of "erodin."

Drenching.—This method of removing lime by means of fermenting bran infusions has also been fully investigated by Wood. The active ferments are two bacteria, named *Bacterium furfuris a and* β, both of which have been isolated. They have no direct action on the hide, but ferment the glucose, which is produced by the action of cearalin, an enzyme discovered by Wood in bran extract, on the starch which is present. Hydrogen, carbon dioxide, and nitrogen, and acetic and lactic acids, are the principal products of reaction. The fermentation is allowed to proceed until small blisters, caused by the evolution of gas in the fibre of the skin, make their appearance on the surface.

Souring of Bark Liquor.—Thick hides intended for sole leather, etc., are tanned in the tan-pit, where it is uncertain whether fermentative action takes place or not. The more delicate skins, however, are tanned in an aqueous extract of tanning materials known as bark liquor. This extract gradually goes sour on standing, and this acidification has been shown to be due to lactic bacteria. The lactic acid formed has a highly favourable influence on the quality of the leather produced, pure tannin giving a hard and cracking product. The tanner consequently likes to see his bark liquor become sour, and generally accelerates the change by inoculating the fresh liquor with old soured liquor.

Saponification of Fats by Enzymes.

It has been well known for a considerable time that the seeds of the castor oil plant contain a soluble ferment, lipase, which decomposes fats into glycerin and fatty acids in a similar manner to mineral acids or alkalis.

Quite recently an industrial process for the hydrolysis of fats has been worked out, chiefly by Connstein, which depends on the action of the castor-oil enzyme. The seeds are husked and ground with a little of the oil to be saponified, then mixed with the remainder of the oil and a little acetic acid. The mass is stirred vigorously (generally by air blowing) until an emulsion is formed, and decomposition sets in almost at once. After twenty-four hours, when the reaction is completed, the mixture is heated to 80° to kill the enzyme, dilute sulphuric acid being added to facilitate separation, and allowed to stand; the fatty acids form a layer on top, and the aqueous glycerin solution is run out from underneath. A further separation is effected by again stirring and allowing to stand. A typical saponification of linseed oil gave the following results:—

Oil	1000 lb.
Crushed seeds	66 „
Water	400 „
80 per cent. acetic acid	3 „
28 per cent. sulphuric acid . . .	20 „
Temperature of action 20° C.	

Products:	Glycerin (1·233) . . .	96 lb.
	Fatty acids . . .	1010 „

The decomposition thus seems to be complete, although the researches of Kastle and Loewenhart went to show that lipolytic actions are reversible. These investigators succeeded in synthesising glycerin esters, and also ethyl butyrate by means of the lipase obtained from pigs' liver. There is no doubt, however, of the commercial application of the Connstein process.

The velocity of the reaction depends greatly of course on the quantity of seeds used, thus 3·5 per cent. produced 77 per cent. of fatty acids in twenty-one hours, whilst 7 per cent. produced 79 per cent. in six hours.

Owing to the introduction of organic impurities to the fatty acids and glycerin by the use of seeds, attempts are being made to employ active preparations of the ferment obtained by precipitation.

Fokin has shown that besides castor-oil seeds, those of jequirity and also celandine can be used. The latter especially are said to contain as much of the active fat-splitting constituent as the castor-oil seeds themselves, and recently the existence of a similar lipolytic enzyme in the seeds of the Para rubber-tree has been observed in the Scientific and Technical Department of the Imperial Institute (*Bulletin of the Imperial Institute*, Vol. II., p. 158).

Japanese Lac.

The latex producing the black lac of the Japanese and Chinese is a milky fluid somewhat resembling cream, obtained by making incisions in the trunks of certain trees. In contact with the air it goes brown, and becomes coated with a black pellicle which is insoluble in the usual solvents and unattacked by acids and alkaline solutions.

Moisture is necessary for the production of the lacquer, as in dry air the latex becomes only reddish and viscid.

Bertrand has shown that the change occurring during the manufacture is due to an enzyme, an oxidase, which he terms laccase. He proved that it was by the combined action of the

laccase and oxygen on "laccol," a soluble material, that the conversion of the latex into lac is effected.

The latex is really an emulsion of laccol in a highly-concentrated solution of laccase.

Other Enzymes.

Of the remaining enzymes which are prepared industrially for general use, or whose action is involved in industrial processes, it is only necessary to mention the digestive ferments, pepsin, trypsin and papain which are employed medicinally, and that large class of bodies known as oxidases, of which the aforementioned laccase is an example.

The colour of cider and of the juice of the beetroot, the browning in air of various fruits, the occasional decoloration of red wines and the various colours assumed by mushrooms when cut, are all due to the action of oxidising ferments, the co-action of atmospheric oxygen being of course necessary.

Probably also the darkening of india-rubber after coagulation of the latex is due to a similar enzyme action.

OLIVE-OIL INDUSTRY.

THE olive-tree is believed to be a native of Asia Minor and Syria, and thence to have been introduced in very remote times to Egypt and Greece, and before 600 B.C. to Italy, becoming thoroughly naturalised in the latter country and in the Spanish peninsula.

The Mediterranean region long held in the olive-oil trade a position of predominance, which may be to a large extent occupied in the future by the Cape and Australasia.

In this as in other fruit-oil industries, primitive appliances suffice to perform the simple operation of expressing the oil from the fruit-pulp, and therefore the business is not beyond the powers of small proprietors. Seed-oil industries, on the contrary, have a tendency to fall exclusively into the hands of owners of large oil-factories, since powerful machinery is necessary for the expression of oil from seeds. Owners of small

olive groves sometimes co-operate in working a factory in common; but most of them still prefer to go on working their own little "oileries."

In connection with the development of the olive-oil industry in British Colonies, a manual recently written by M. Dugast, and published by Gauthier-Villars of Paris, dealing with olive cultivation as practised in the countries of southern Europe and northern Africa, is of importance.

Varieties of Olives.

The weight and form of the fruits furnish a means by which cultivators are accustomed to distinguish varieties. Probably the greatest extremes are on the one hand the small wild olive, and on the other the large Seville olive, the pulp of the latter being very thick, and the weight of the fruit often more than ten times the weight of the fruit of the wild plant. Of the Algerian olives, the "Mizrana" is light and the "Limi" heavy. In Tunis the "Chemlal" is light and the "Zarassi" heavy. Differences of weight are usually attributable to the pulp, the stones varying only within narrow limits. The hard stone encloses an oleaginous kernel: the average weight of the stone is approximately ten times that of the kernel. In the "Saheli," "Picholine," and "Limi" varieties, the weight of the pulp is about ten times the weight of the stone: in the "Saïal," "Carniale," "Ogliarola," "Cellina," and "Racciopa" about five times; and in the "Azemour d'Azeffoun" and "Little Chemlal" there is about as much stone as pulp.

As regards form, some olives, such as the "Manzanilla," one of the most widely-cultivated varieties in Spain, are almost spherical; but the majority, including the "Limi," which comes from Tlemcen in Algeria, are oblong; while a few are long and narrow. The "Fort National," one of the latter group, is pointed. In some varieties the surface of the stone is smooth, in others rugose. In all, the pulp, even when fully ripe, adheres closely to the stone, the residue and oil-cake made from it being consequently rich in oil.

Formation of the Oil.

Little is known as to the physiological processes occurring in the interior of the fruit and leaves, the principal result of these

processes being the accumulation of oil. The fruit matures slowly, taking about ten months to ripen. When unripe it contains chlorophyll, tannin, and abundance of starch ; as it ripens, chlorophyll and carbohydrates disappear, and oil gradually accumulates in the form of oil-drops in the cells of the kernel and the pulp.

The quantity of oil, both in the kernel and in the pulp, attains a maximum as the fruit matures, and then slowly diminishes. The proportion of unsaturated acids in the oil decreases and that of saturated acids increases during ripening, so that oil yielded by immature olives contains comparatively little solid fat. In diseased and injured olives the proportion of solid fat is higher. Other things being equal, the quantity of oil is higher in the pulpy varieties than in those with large stones. Among mature olives of equal size, the lightest in weight are the richest in oil. The proportion of free acid in the fruit is lowest at the time of complete maturity, so that from healthy fruits very little free acid gets into the extracted oil. Free acid is more liable to appear in oil derived from diseased, unripe, or over-ripe fruits.

Soil is known to have a marked influence upon both quantity and quality of the oil. Olive groves on marly, granitic or calcareous land produce a finer and more fluid oil than those on heavy clay or rich humid soils of any kind. The decrepit trees on arid rocky places bear olives rich in fine oil.

The proportion of oil in the fruit varies from 1 to 9 per cent. in the case of the wild olive in the fresh state, and from 21 to 28 per cent. in the dry state. Decision as to whether it is best to extract the oil or to use the olives to make a preserve, largely depends upon the variety. The "Verdale" variety is useful as a preserve, but yields an oil of inferior quality. The "White Caillet," on the contrary, makes an indifferent preserve, but yields a good oil. The "Picholine" and "Lucca" are used for preserves as well as for oil. As a general rule the medium-sized varieties are best for both purposes. The "Cordovil" olive of Portugal and Spain is of moderate weight and in the dry state contains oil to the amount of from 40 to 50 per cent. The variety most widely cultivated in Portugal is the "Gallega," which is of light weight, and contains 40 per cent. of oil. In France

the "Pigalle" generally contains more oil than the "Argental," in Tunis the "Hobb Reguerig" more than the "Djeheli," in Algeria the "Garel" more than the "Beksi." Allowance must always be made for differences of locality, which often considerably modify the yield.

Picking and Storing.

The exact time of maturity is ascertained by tasting the fruit. The taste is less astringent and acid when the fruit is ripe than when it is unripe, and the colour becomes rather darker. The fruit does not freely drop from the tree until it is ripe. The time of maturity depends upon the climate. November is usually a good month for picking in Italy, December in Portugal, while in Algeria and Tunis picking begins in November and goes on practically all through the winter, and in France picking often takes place during severe cold in mid-winter. Picking is usually effected by knocking off the olives with a pole. This damages the tree and the next year's growth, and picking by hand by the aid of a short ladder is better. The most practical plan is to pick by hand the fruits within reach and then knock off the rest with a pole. Cloths should be spread on the ground to catch the fruits. Injured fruits should not be allowed to remain in contact with the sound ones.

The only way in which first quality olive oil can be obtained is by extracting the oil from the fruit immediately after picking. Unfortunately it is not always possible to do so if the crop is a heavy one. The factories which buy the olives to make oil generally cannot get them as fresh or as regularly as they wish. Under such circumstances provision has to be made for storing the olives. Soon after picking, fermentation tends to set in, causing the oil to become rancid. One method of storing is to spread the olives out one layer thick on tables, but the results are not entirely satisfactory, and if left more than eight or ten days the olives deteriorate. Another method is to keep the olives in water, the water being constantly renewed. This entails some loss of oil. Better results seem to be obtained in Algeria by putting them into boiling water. Another method is to put the olives into tubs

and crush them until the surface is covered with a coating of oil which serves to protect the olives beneath. Another method consists in salting the olives and drawing off the brine. They can be kept in that way for a month, but not more. The method recommended as probably the best consists in salting and leaving the olives bathed in the brine, in which they may be kept for five months. There is an apparent loss of some of the oil, about 9 per cent. being drawn off by the salt. This oil, however, is recoverable from the brine, and is of fairly good quality. Oil extracted from stored fruit is stated never to be so good as that extracted from fresh fruit.

Milling, Expressing and Refining of Olive Oil.

After being picked, and provided that they are uninjured, the olives may be allowed to remain up to eight days in a cool place, as a little keeping facilitates extraction of the oil.

Broken fruits, leaves and *débris* should be removed by sifting, and olives covered with earth should be washed. There are several different kinds of mills. Those situated on rivers are usually worked by water power, other large mills by steam, and small mills by horse or hand power. There are over four thousand mills in Algeria, of which over two thousand are in the Bougie district. A mill of a usual type consists of a heavy vertical grindstone revolving above a horizontal stone table, the olives being crushed between the grindstone and the table. Instead of using a mill, small cultivators often use a simple press not unlike that used in making cider.

The next operation is expression. Presses of various kinds are in use, differing considerably in power. The chief defect of many of them is that they are not sufficiently powerful to extract a reasonable proportion of the oil. Modern presses may be seen at work in the South of France, in Tunis and Portugal, and particularly at Bari in Italy. The oil can be expressed more readily in warm than in cold weather. In cold weather hot water is sometimes mixed with the pulp to raise its temperature, but it is better not to use water for that purpose, and instead to gently warm the utensils and apparatus, taking care to avoid excessive heat.

Pulp kept cool yields a smaller quantity of oil, but the oil is of better quality. The pressure must be under control, so that it may be regulated and gradually increased. Excessive pressure increases the quantity at the expense of the quality. Light pressure should be applied to extract the "virgin oil," which comes out of the pulp first, and subsequently stronger pressure to extract "common oil." More oil can be extracted by injecting steam and applying still stronger pressure ; as a rule this, the third quality of oil, is only fit for use as "industrial oil."

On emerging from the press, the oily liquid contains *débris* and substances other than oil in suspension. The *débris* can be strained off. The oil, being light, rises to the surface, and can be separated from the juice, which sinks, by decantation. Cold water is added to the oil, and the emulsion thus formed is allowed to stand. The oil rises as before to the surface, the impurities settling to the bottom. It is best to hasten the process by filtration, otherwise the oil, if left too long in contact with the impurities, undergoes deleterious alteration. Filtration is, moreover, ultimately indispensable as a means of completing the refining of the oil. Filtration is effected under pressure, air being excluded. Only by thorough filtration is it possible to produce the limpid oils for which Nice and Bari are famous. The impurities contained in oils which have not been well filtered cause gradual deterioration of the oil.

Composition of the Oil.

Olive oil is a mixture of glycerides of oleic, palmitic, and stearic acids. The most abundant and the most important of these is olein, the glyceride of oleic acid. The glycerides of palmitic and stearic acids are solids, and tend to separate out from the oil as a turbid, semi-solid, and ultimately solid substance, distinct from the more limpid oil, in which olein is the main constituent.

The most limpid oils are used as a preservative for sardines and other fish, and such oils will keep for a long time without becoming turbid. For that purpose, Italy, and particularly the Bari district, produces large quantities of fine oil. Next in quality are the fine table oils. Inferior oils

are used for lubrication and making soap; if kept long they degenerate, give out a disagreeable odour, and become turbid as a result of gradual separation of the palmitin and stearin. These solid fats may be removed by the process known as "demargarination," yielding a second-rate oil.

Preservation of the Oil.

If moisture is allowed to remain in the oil, fermentation occurs on keeping. Exposure of the oil to light, air, or heat is injurious, giving rise to chemical changes.

Olive Oil-cake.

However powerful a press may be, it can never extract all the oil from the pulp. The residue contains oil to the amount of at least 5 per cent., and often more than 10 per cent. The residue is used to make oil-cake. Large factories turn out a hard oil-cake which contains but little oil. The oil-cake produced by small factories as a rule contains more oil, and is less compact and more friable in appearance.

NOTICES OF RECENT LITERATURE.

NEW BOOKS.

A MANUAL OF FORESTRY. Vol. III. FOREST MANAGEMENT. By William Schlich, C.I.E., Ph.D. Third Edition, Revised. Pp. xiv—405. (London: Bradbury, Agnew & Co., Ltd.)

The previous volume, of which a notice appeared in the Bulletin, Vol. ii., p. 211, deals with practical sylviculture; the present volume is concerned with the theoretical considerations included under forest management. Beginning with the measurement of the individual tree, the author passes on to the measurements of woods, the valuation of forests, the increment of growth and the yield, all of which must be understood before it is possible to prepare forest working plans.

The former practice of estimating the amount of timber in a tree, or the more difficult estimation for a collection of trees by ocular inspection cannot be regarded as satisfactory, and it is necessary to devise more suitable methods. A general method and several modifications are described, which depend upon the measurement of the diameter of a number of sample trees from which the volume is obtained by means of volume tables constructed from experimental data.

The choice of rotation, *i. e.*, the period of years which elapses between the formation of a wood and the time when it is finally cut over and regenerated, is one of the most important measures in forest management. It is generally decided by financial considerations, but in the case of State forests the economical aspect may be set aside in favour of a rotation with some particular purpose, such as the supply of timber for special requirements.

The preparation of forest working plans is at once the most responsible and difficult work, which falls to the forest officer and requires considerable experience. For this reason, and because the details which have to be taken into account are so varied, Dr. Schlich treats the subject on broad lines. The first step is to collect statistics with regard to the nature and quantity of the growing stock, past yields and general conditions. The statistical report based upon these returns can then be utilised for drawing up a plan for sub-dividing the area into sections, for deciding the general lines of management and preparing an estimate of future profits. It will be evident that experimental data are the foundation of all calculations connected with forest management; these are at present wanting for Great Britain, so that the author rightly points out that the compilation of figures and tables is a most pressing requirement for the progress of British forestry.

THE WORLD'S COMMERCIAL PRODUCTS. By J. A. Slater, B.A., LL.B. (London: Sir Isaac Pitman & Sons, Ltd., 1905.)

This book is a dictionary, arranged alphabetically, of the principal products which are of importance in commerce. Many of the subjects dealt with are natural products, mineral or vegetable, and for that reason the book is of special interest to residents in

the British Colonies and Dependencies. It should also be useful, for general reference, to students of commercial geography and similar subjects, in which a general knowledge of the nature of the products obtainable from different countries is necessary.

The information supplied with regard to the various products dealt with is on the whole quite accurate, though occasionally there are omissions of information which would have been useful, and there are a few mistakes. Under "Essential Oil of Almonds" no reference is made to the fact that much of the oil now sold under this name in commerce is made artificially; similarly, although vanilla is dealt with there is no reference to artificial vanillin, which has largely replaced it as a flavouring agent.

The article on "Alum" refers to "potash alum" only, although "ammonia alum" is at least equally important so far as commerce in the United Kingdom is concerned. The paragraph referring to "Cardamoms" and to "Coca" make no mention of the fact that both these materials are produced, the former almost exclusively, in Ceylon, though mention is made of the quite unimportant output of "Ipecacuanha" from Ceylon. The article on "Cola Nut" states that this material possesses properties similar to those of Cinchona bark, which is scarcely accurate, since cola contains "caffeine" and belongs to the group of stimulants which includes tea, coffee, maté and guarana. Under "Copal" it should have been mentioned that considerable supplies of this resin are obtained from the West Coast of Africa.

The author takes a very optimistic view of the cotton trade of the United Kingdom, which, large as it is, is not "equal to that of the rest of the world put together." Roughly speaking, the cotton trade may be divided into three equal portions, one of which is taken by Great Britain, another by the United States of America, and the third by the rest of the manufacturing countries of the world taken together. One curious inaccuracy noticed in this book occurs in the article on "Sumac," which is described as yielding a bark extensively used in the preparation of leather. The sumac used for tanning consists, not of the bark but of the leaves of the sumac plant (*Rhus cotimus*). "Wurrus" also is not a synonym for "Kamala," but an adulterant occasionally found in this dyestuff.

Such inaccuracies as are referred to in the foregoing paragraphs are almost unavoidable in a first edition of a book dealing with so great a variety of products as are mentioned in this volume, and their occurrence does not detract from the valuable character of the book as a whole.

The book is well printed, the type being clear and of fair size. In this connection it may be suggested to the author that he should conform to the usual plan of printing botanical names with the generic name beginning with a capital letter, and that in selecting botanical names, those given in the *Index Kewensis* as authoritative should be adopted.

THE COALFIELDS OF GREAT BRITAIN, THEIR HISTORY, STRUCTURE AND RESOURCES, WITH DESCRIPTIONS OF THE COALFIELDS OF OUR INDIAN AND COLONIAL EMPIRE AND OF OTHER PARTS OF THE WORLD. By Edward Hull, M.A., LL.D., F.R.S. Fifth Edition, revised, embodying the Report of the Royal Commission of 1904. Pp. xxii and 472. (Hugh Rees, Ltd., 1905.)

The first edition of this book appeared in 1861. Since that time the author has been a member of the Royal Commissions appointed in 1866 and 1904 to consider the question of the extent and availability of the coal supplies of the United Kingdom, and the information obtained by these Commissions has been utilised in the present edition.

After dealing with the mode of formation and preservation of coal, the author describes in turn the different coalfields of the United Kingdom, and states the grounds on which he believes in the occurrence of two coal-bearing troughs in the south of England. A brief description follows of the coalfields of other parts of the world, especially the British Colonies and India.

The author discusses the limit of depth at which coal mines can be worked, and furnishes an estimate of the total available supply in the United Kingdom as well as in other countries in Europe.

The book is illustrated by numerous sections and maps showing the distribution and extent of the British coal deposits and the depths at which they occur.

RECENT JOURNALS.

JOURNAL D'AGRICULTURE TROPICALE. (Paris: J. Vilbouchevitch.)

This journal is published monthly and deals with the cultivation, utilisation and commercial exploitation of economic products, especially those of the French Possessions. The contents comprise articles on natural products, a commercial section consisting of a series of market reports, notices of the proceedings of various agricultural and similar societies, and reviews of recent books dealing with the cultivation and production of various crops. In the number for May 31, 1905, the following subjects are dealt with.

The employment of rice in the brewery as a partial substitute for malt and the special equipment required for the purpose form the subject of an article of M. P. Petit, Director of the School of Brewing, Nantes. This is followed by a short account of the International Congress on Rice Cultivation which was held at Mortara, Italy, in 1903.

The differentiation of the various species of *Sansevieria*, the "bowstring hemp" plants, is illustrated by reference to the collection in the "Muséum d'Histoire naturelle" at Paris, and notes are added on the methods of propagation best suited to the different species.

In an article by M. F. Main on the sugar-cane industry, a description is given of various machines employed for loading the sugar-cane at the plantation and its discharge at the factory.

An interesting account of the cultivation of cacao at a large plantation in Venezuela forms the subject of a paper, the materials for which were supplied by M. Cibot. The plantation covers about 3,000 acres and is mainly devoted to cacao trees grown under the shade of the Central American rubber tree *Castilloa elastica*. The results obtained in this plantation have demonstrated that *Castilloa* can be cultivated among cacao trees without interfering in any way with their productiveness, and that a good yield of rubber can also be obtained.

The commercial reports give details of the demand for, and the current prices of, rubber, cotton, coffee, cane-sugar and

various fibres in the French markets. Lists are also given of the position of the chief African agricultural products in the Liverpool market and the sale of French Colonial products in the Havre market.

The journal concludes with a series of notes on current events, which in this number include the programme of the Agricultural Section of the Colonial Congress at Paris, a short account of the proceedings of the French Colonial Rubber Association, a notice of the publications of the French Colonial Cotton Association, and references to various subjects of economic and agricultural interest.

DER PFLANZER.—This is a new monthly publication issued by the Biological-Agricultural Institute at Amani, in German East Africa, with the co-operation of the *Usambara Post*, which is intended to give advice on agricultural matters to planters at work in the German Colony.

Four numbers of the publication have so far been issued, and, as is to be expected at the present time, various aspects of cotton cultivation occupy a considerable amount of the space in these. Thus in No. 1 Dr. W. Schellmann summarises the results of American experience in the management of cotton soils; in No. 2 Herr Linder, District Inspector of Agriculture, describes the climate and soil of Lindi Province and recounts the experiments made there recently in cultivating cotton ; and in No. 4 there is a general article on the progress of cotton-growing in the colony by Herr Eismann, who has had samples of Egyptian cotton grown in German East Africa valued in Liverpool at 8¾*d.* and 9*d.* per lb. Connected with this subject is an article on the methods available for the destruction of mice, rats, and similar rodents. Pests of this description have done much damage to cotton crops in various British Colonies by dragging the cotton out of the bolls in order to get at the seed. The various poisons suitable for use in such cases are mentioned, and the best methods of applying these are given.

Other articles dealing with the cultivation of ipecacuanha, the mechanical preparation of rubber—a subject which is now occupying attention both in the Straits Settlements and in Ceylon—and the extraction of fibres are included. Each number of *Der Pflanzer* also contains the results of the chemical examination

and commercial valuation of new East African products, made generally by the German Colonial Economic Committee in Berlin, which undertakes on a small scale for the German Colonies work similar in character to that done by the Imperial Institute. Among German East African products recently examined in this way are Mangrove barks, the bark *Acacia decurrens*, which contains tannin and might be worth attention in British Colonies where this tree grows, graphite, vetiver oil and lemongrass oil, the sample of the latter being valued at 24 marks per kilogramme. It will be seen that this new publication is likely to be of great interest to planters, merchants and others interested in the exploitation of natural products, and in conjunction with the occasional *leaflets* and quarterly *Journal* issued by the same institution, should do much to aid in the development of planting and agriculture throughout East Africa.

BULLETIN

OF THE

IMPERIAL INSTITUTE

INDIAN AND COLONIAL COLLECTIONS.

RECENT ADDITIONS.

CEYLON COURT.

THE COCO-NUT PALM AND ITS PRODUCTS.

AMONG the Ceylon exhibits recently received from the St. Louis Exhibition is an extensive series of the products of the coco-nut palm, together with a number of photographs illustrating the habit of the tree and the methods employed in the manufacture of desiccated coco-nut in Ceylon.

The incorporation of these specimens into the Colonial Collections has necessitated the complete re-arrangement of the coco-nut exhibit in the Ceylon Court, which now includes almost all the important products of the palm; specimens of timber, coir, oil, poonac, arrack and sugar being exhibited.

The coco-nut palm (*Cocos nucifera*, L.) is a tall graceful tree bearing a crown of large feathery leaves and spikes of small flowers. The cylindrical trunk rises to a height of from sixty to a hundred feet, and may be as much as two feet in diameter; its external surface is marked with circular scars indicating the position of former leaf-bases. The leaves attain a length of about eighteen feet, and are attached to the stem by fibrous sheathing bases of great strength. The unisexual flowers are arranged on branching spikes and are enclosed, while immature,

in a sheath or spathe which finally splits open. Each spathe yields from eight to twenty nuts, and the produce of an average healthy tree in Ceylon is about fifty or sixty nuts per annum.

The coco-nut palm is extensively cultivated in most parts of the tropics, but its country of origin is not definitely known. The majority of other members of the genus *Cocos* are natives of tropical South America and the West Indies, and arguments have been put forward in favour of an American origin for the coco-nut palm itself, but according to De Candolle there is reason for supposing *Cocos nucifera* to be indigenous to some parts of the Eastern tropics, possibly the Malay Archipelago. The wide distribution of the plant has been attributed to the dissemination of its fruits by marine currents, and the palm is commonly found near the sea, and attains great luxuriance on the seashore itself.

Cultivation.—The coco-nut palm is largely cultivated in Ceylon, forming one of the staples of the agriculture of the island; it is estimated to cover about 800,000 acres. The principal nut-growing region extends as a belt along the south-west coasts and the shores of the Batticaloa district of the Eastern Province and the Jaffna peninsula in the north. "Of late years a great deal of land has been planted more inland in the West and North-west Province, where the Government has sold extensive areas for the purpose." (Ferguson, "*All about Coco-nut Planting*.") In the dry north and north-western districts, the coco-nut is supplanted, to a large extent, by the Palmyra palm (*Borassus flabellifer*, L.).

The cultivation is chiefly in the hands of native planters, and every Sinhalese hut has a few palms growing near it; in recent years, however, a number of plantations have been laid out by Europeans. The natives recognise a large number of varieties of the coco-nut, of which the most important are:—(1) the ordinary form; (2) the Tembili or "King Coco-nut," an oval, bright, orange-coloured nut containing a pink endosperm; (3) smaller forms.

The coco-nut palm thrives with an average mean temperature of 80° F., and an annual rainfall of from 60 to 80 inches. The best soil is that found in the alluvial flats along large streams which are not liable to excessive or prolonged floods, but

excellent results are obtained in deep sandy or gravelly loams such as occur in many parts of the Matale Valley. The nuts are planted out in seed-beds from January to April, and again in August, providing that the rains are not too heavy. Transplantation is carried on from the second to the sixth month after the appearance of the shoots, the seedlings being placed eight to ten yards apart according to soil and situation.

At the end of the fifth year the plant possesses a definite trunk, and when nine or ten years old, begins to bear abundantly. Throughout the life of the tree, the cultivator has to contend with the ravages of several pests, particularly boring beetles. Rats, flying-foxes (*Pteropus*), and flying squirrels (*Pteromys*) do considerable damage by feeding upon the young nuts, and the terminal bud or "cabbage." Further, the plantations must be efficiently protected against the depredations of porcupines, cattle, wild pigs, and in some districts, elephants.

Products.

Timber.—Coco-nut wood, which is derived from the denser outer part of the trunk, is close-grained, hard and heavy. It is light-brown in colour, with dark reddish-brown to black markings indicating the position of the vascular bundles. The trade name is "Porcupine Wood."

The suitability of the timber for ornamental and other purposes is well illustrated by the examples in the Ceylon Court, notably by the screen on the south side of the Court, which is a fac-simile of the gate at Yapahu, one of the ancient capitals of Ceylon. In addition to whole polished trunks, rafters employed by the natives in building their huts are shown, together with articles such as tables and chairs, an exhibition table-case, writing-desks, picture-frames and boxes.

Coir Fibre.—The exhibit of this important fibre is now fairly representative. Several small bales of different grades are shown, together with specimens of various kinds of rope, mats and matting of native manufacture.

Coir is derived from the tough fibrous husk of the coco-nut. The best fibre is said to be obtained from nuts gathered before they reach maturity, and when about ten months old. If cut earlier than this, the husks yield a weak fibre, and the fibre from mature nuts is coarse, hard and difficult to manufacture.

In preparing coir, the husks are split off the nut by forcing them against a pointed implement fixed in the ground. A skilful native is able to clean about 1,000 nuts per day. The next process consists in soaking the husks in water. Various methods of soaking are practised; in some localities the soaking pits contain brackish water, in others fresh water is used, but the most approved plan is to soak the husks in water contained in brick, iron or wooden tanks into which steam can be admitted to warm the water. Great care is taken to avoid over-soaking. When the husks are sufficiently softened, they are beaten with heavy wooden mallets, and then rubbed between the hands until all the interstitial tissue has been removed from the fibre, which is then ready for drying. In European factories, machinery has been substituted for hand labour. The husks are crushed in a mill, and the fibre removed in an "extractor" by means of revolving cylinders armed with steel teeth. The short fibres, together with the dirt, are removed by sifting in wire baskets.

Coir fibre is clean, coarse, stiff, and very elastic. It does not possess great tensile strength, but on account of its property of withstanding the prolonged action of sea-water, is extensively used in the East for making rope and cordage, and to a less extent for the same purpose in this country. It is largely employed in Europe for manufacturing mats and matting and is stated also to find application as a material for press or filter-bags used in sugar-making, candle-making, oil-refining, and other industries. Qualities of fibre unsuited for these purposes are used for making brooms and brushes; several grades of such fibres, together with sample brushes, are exhibited in the table cases in the Court.

Oil.—The oil derived from the endosperm or "kernel" of the nut is one of the most valuable of the products of the coco-nut palm. It was formerly largely used in the East as an illuminant, but its use for this purpose has been somewhat restricted in recent years by the extensive importation of mineral oils from America, Russia, and Burma. The natives use coco-nut oil for soap-making and for anointing the body.

In Europe the chief application of the oil is in the soap and candle industries, for which purposes it is very suitable. Of late

years coco-nut oil has met with serious competition from the large and increasing imports of palm kernel oil (*Elæis guineensis*, Jacq.) from the West Coast of Africa. In this connection it is interesting to note that *Elæis guineensis* has been planted in Ceylon and grows well in Lower Hapatale and Kelani Valley.

The soap manufactured from coco-nut oil is firm and white, and has—in common with soaps made from the oils of other palms, such as the West African palm kernel and the Cohune palm (*Attalea cohune*) of South and Central America (see this *Bulletin*, 1903, Vol. i., p. 25)—the property of readily forming a lather with sea-water, a fact which renders it especially valuable for use on board ship.

In India and Ceylon the "kernels" are usually crushed in primitive mills worked by oxen, the amount treated per day being about 130 lb., yielding 40 quarts of oil. A model of a native crushing mill is shown in the Court.

The "cake" left after the extraction of the oil is known as "poonac," and is used as a food for cattle and poultry; it is also employed as manure, especially on coco-nut plantations. Specimens of the chief commercial varieties of coco-nut oil and poonac made in Ceylon are exhibited.

In commerce three qualities of coco-nut oil are met with:—

(1) *Cochin oil.*—The finest and whitest quality, prepared in Cochin (Malabar).

(2) *Ceylon oil.*—Prepared in Ceylon, whence it is exported in large quantities. It is not so good as Cochin oil, the superiority of the latter probably being due to better methods of cultivating the palm, and to cleaner methods of expressing the oil.

(3) *Copra oil.*—Expressed on a large scale in Europe from copra, *i. e.* the dried kernels imported from Ceylon, India, Mauritius, Seychelles and elsewhere.

Preparations of purified coco-nut oil are employed for edible purposes in England under the names of "vegetable butter," "nucoline," etc.

Desiccated coco-nut is also exported to a large extent from Ceylon. No specimens are at present available in the Court,

but there is a good series of photographs illustrating the chief processes through which the nuts have to pass in the preparation of this commodity.

Other Products.

Toddy.—The fresh unfermented juice of the coco-nut palm, obtained by tapping the flower stalk just before flowering, is largely consumed as a beverage in India and the East. The inflorescence can first be profitably tapped when about one month old. The toddy-drawer ascends the tree, and cuts off about one inch of the tip of the spathe, which has been tightly bound with a strip of coco-nut leaf to prevent expansion; the cut end is then gently hammered until the young flowers are crushed, and when this is effected the stump is carefully bound up with a strip of a young leaf. This process is repeated for several days, the spathe meanwhile being trained to bend downwards. The sap flows towards the wounded parts, and after a few days is collected in an earthenware vessel fixed to the end of the spathe. The toddy-drawer mounts the tree twice a day and empties the liquor into a vessel of closely-plaited palmyra fibre, and repeats the process of cutting the spathe. The liquor is consumed either in the fresh state or after fermentation has set in, when it is known as "toddy."

The fresh liquor when boiled down over a slow fire yields a sweet solution, which, on further concentration, crystallises out into the coarse brown sugar known as "jaggery," specimens of which are exhibited. Although generally met with in the crude form of jaggery, coco-nut sugar is capable of being refined by European methods.

A large series of specimens illustrates the various qualities of palm spirit or arrack which is prepared by the distillation of the fermented toddy. The apparatus used in the collection of the toddy and in the distillation of the spirit is exhibited.

Trade.—The exports of the produce of the coco-nut palm in 1903 represented over a quarter of the total value of Ceylon produce, the value being nearly 26,000,000 rupees (£1,730,000). The most valuable product is the oil, followed, in order of their importance, by copra, desiccated coco-nut, poonac and coir. The bulk of the oil goes to the United Kingdom, America, and India, and the copra chiefly to France and Germany, where the oil is

expressed. England and Germany are the principal customers for the coir rope, yarn and fibre.

The following table gives the value of the coco-nut exports from Ceylon during the last few years:—

Articles.	1900 Rs.	1901 Rs.	1902 Rs.	1903 Rs.
Arrack	73,652	72,082	106,332	129,964
Coco-nuts	646,340	773,391	711,918	649,635
Coco-nuts, desiccated	2,237,547	2,314,708	2,870,549	3,104,609
Coir fibre	718,298	700,603	778,174	793,134
Coir, manufactured	9,857	10,561	11,559	9,575
Coir and Rope	120,869	137,462	160,560	207,670
Coir Yarn	1,223,709	854,538	799,705	945,357
Copra	3,930,694	4,540,693	4,098,947	7,531,540
Coco-nut Oil	6,673,171	7,601,233	10,007,860	11,022,596
Coco-nut Shells	13,536	27,060	32,623	51,993
Poonac	970,634	937,474	1,283,264	1,499,820
Quills, Coco-nut Leaf.		150		
	Rs. 16,438,307	17,970,835	20,861,491	25,945,893
	£1,095,887	£1,198,055	£1,390,766	£1,729,726

PHOTOGRAPHS OF ECONOMIC PLANTS.

The Ceylon Court has also been enriched through the Government of the Colony, by an extensive series of photographs of great economic interest. A number have already been placed on exhibition. The chief stages in the cultivation, manufacture and marketing of tea, the staple product of the island, are represented by a collection of twenty-two photographs which afford a fairly complete representation of this important industry and have already proved of interest to enquirers about tea cultivation in Ceylon.

The conditions under which coffee, cacao and cinnamon are produced are similarly illustrated by other series of photographs, showing the habits of these plants, their modes of cultivation, and the preparation of their finished products.

Pictures, illustrating the habit of such economic plants as the famous Talipot Palm of Ceylon (*Corypha umbraculifera*), the Jâk tree (*Artocarpus integrifolia*) and its ally, the Bread Fruit (*A. incisa*), both staple food plants of the natives, the introduced Durian (*Durio zibethinus*) with its malodorous but luscious fruits, are displayed. A panoramic view of Nuwara Eliya affords a good idea of the surroundings of the hill

sanatorium of Ceylon, and a series of native types, the races met with in the Colony.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since 13th June, 1905.

An Account of the Deep-sea Holothurioidea collected by the Royal Indian Marine Survey Ship *Investigator*	By R. Koehler and C. Varey.
Catalogue of the Indian Decapod Crustacea in the Collection of the Indian Museum . . .	By A. Alcock, M.B., LL.D., F.R.S., C.I.E. (*Trustees of the Indian Museum.*)
Insomnia: Its causes and cure. Contributions to Practical Medicine .	By Sir James Sawyer, M.D., F.R.C.P., F.R.S., F.S.A. (*Author.*)
The Oxford Atlas of the British Colonies. Part 1. British Africa .	(*Messrs. Wm. Stanford & Co., Ltd.*)
The Geology of Cyprus . . .	By C. V. Bellamy, M.Inst.C.E., F.G.S., and A. J. Jukes-Browne, B.A., F.G.S. (*Crown Agents for the Colonies.*)
Erythräa und der Ägyptische Soudân	By Professor Dr. E. Dagobert Schoenfeld. (*Dietrich Reimer.*)

Transactions of the Institution of Mining and Metallurgy. Vols. xii. and xiii.	(*Secretary.*)
The Estate Nursery: a handy book for owners, agents and woodmen on the Propagation and Rearing of Forest Trees for planting on private estates	By John Simpson. (*The Country Gentlemen's Association, Ltd.*)
Principal Grant	By William Lawson Grant and Frederick Hamilton. (*Mrs. Patmore.*)
"Verb. Sap." on going to West Africa	By Alan Field. (*Messrs. J. Bale, Sons & Danielsson.*)
Records of the Cape Colony, September-December, 1826 . . .	By G. McCall Theal, D.Lit., LL.D. (*Colonial Secretary.*)
Report of the South African Association for the Advancement of Science, 1904	(*Secretary.*)
Calcutta University Calendar, 1905 .	(*Registrar.*)
New Zealand University Calendar, 1905–1906	(*Registrar.*)
All About Coco-nut Planting . .	By J. Ferguson. (*Messrs. A. M. & J. Ferguson.*)
O Amazonas: Esboço Historico, Chorographico e Estatistico até o anno de 1903	By Lopes Goncalves. (*The Consul-General for Brazil.*)

Zanzibar in Contemporary Times: a short history of the Southern East in the Nineteenth Century . .	By Robert Nunez Lyne. (*Messrs. Hurst & Blackett, Ltd.*)
Handbook for East Africa, Uganda and Zanzibar, 1905 . . .	(*Colonial Office.*)
Records of the Cape Colony, January–October, 1827	By G. McCall Theal, D.Lit., LL.D. (*Colonial Secretary.*)
Round the Rand: Present position and prospects of Rand Mines .	By J. W. Broomhead. ("*Financial Times.*")
Methods of Chemical Control in Cane Sugar Factories	By H. C. Prinsen Geerligs. (*The Proprietors of "The International Sugar Journal."*)
Proceedings of the Royal Colonial Institute. Vol. xxxvi. 1904—1905	(*Secretary.*)
Chemistry for Engineers and Manufacturers. Vol. ii. Chemistry of Manufacturing Processes . .	By Bertram Blount and A. G. Bloxam. (*Messrs. Charles Griffin & Co., Ltd.*)
The Bermuda Pocket Almanack, Guide and Directory for 1905 .	(*Publishers.*)
The Medical and Pharmacy Register for the Colony of the Cape of Good Hope, 1903–1904 . .	(*Messrs. J. C. Juta & Co.*)
Proceedings of the Rhodesia Scientific Association. Vol. iv. 1903–4, Vol. v. 1905	(*Secretary.*)
Commercial Year-book of the Birmingham Chamber of Commerce, 1905	(*Manager.*)

SCIENTIFIC AND TECHNICAL DEPARTMENT.

REPORTS ON RECENT INVESTIGATIONS.

INDIAN VEGETABLE FLOSSES OR "SILK COTTONS."

THESE samples of Indian vegetable flosses were forwarded by the Officiating Reporter on Economic Products to the Government of India, with a request that the specimens might be examined and their commercial value ascertained.

Description of Specimens.

The specimens forwarded for examination were as follows :—

No. 1.—" Pod of *Eriodendron anfractuosum*."

No. 2.—" Pod of *Cochlospermum Gossypium* from Bundelkhund, United Provinces."

These pods would possess no commercial value in this country, since it would not prove remunerative to extract the floss in Europe.

No. 3.—Registered No. 17,742—1. " Floss from *Cochlospermum Gossypium* from Bundelkhund, United Provinces."

This floss was of a dirty cream colour and contained a small quantity of seed. It was aggregated into flocks and was harsh and only slightly resilient. The staple was irregular in length but on the whole very short.

No. 4.—Registered No. 19,553. " Floss from *Cochlospermum Gossypium* from United Provinces."

This material resembled No. 3, but contained a larger proportion of seeds and fragments of leaves. The staple was very irregular in length.

No. 5.—Registered No. 19,397. " Floss from *Calotropis gigantea* from Kishengarh, Jaipur."

This material had a pale cream colour, and was fairly clean, containing only a few fragments of fruit. It had a brilliant gloss and was softer and more resilient than any of the other specimens. Its staple was irregular and varied in length from 25 to 35 millimetres (1·0 to 1·4 inches).

Chemical Examination.

The three flosses were chemically examined in the Scientific and Technical Department of the Imperial Institute and the results so obtained are given in the following table, which contains for convenience of comparison the results yielded by a sample of Java "kapok," and also by a specimen of the floss of *Calotropis procera* which was examined in the Department in 1897.

Registered No. of Specimen.	Origin.	Moisture, Per cent.	Ash. Per cent.	Cellulose. Per cent.
17,742—1	Cochlospermum Gossypium	10·2	3·15	46·3
19,553	Cochlospermum Gossypium	10·0	4·4	45·9
19,397	Calotropis gigantea	9·3	2·7	64·3
	Java "kapok"	10·9	1·3	64·3
	Calotropis procera	9·0	3·0	69·8

A comparison of these figures shows that the samples of *Cochlospermum* floss are decidedly inferior to the Java "kapok" and *Calotropis* flosses with regard to the amount of cellulose which they contain. The *Calotropis gigantea* fibre is equal to the "kapok" in this respect, whilst the *Calotropis procera* is somewhat richer in cellulose. All these flosses, however, contain a much smaller proportion of cellulose than cotton, which under similar conditions yields from 95 to 96·5 per cent. Their deficiency in this constituent accounts for their poor tenacity, and it is possible that even if the mechanical difficulties encountered in spinning such materials were overcome, the resulting fabrics would deteriorate so rapidly that no demand for them could be maintained.

Utilisation of Vegetable Flosses.

As Textile Materials.—The best-known vegetable floss is "kapok," derived from *Eriodendron anfractuosum*, and produced principally in Java, but also to a small extent in India. Numerous attempts have been made to utilise this product as a textile material, and it has been frequently stated that these experiments have been successful, and that the large quantities of this material now annually imported into Holland and Germany are utilised in this way. Careful enquiries have been made from experts in both these countries during the course of the present investigation, from which it would appear

that although experiments are still proceeding, no process has yet been devised whereby this material can be spun on a commercial scale.

It has been suggested that "kapok" might be used for the manufacture of artificial silk (see this *Bulletin*, 1904, Vol. ii., p. 266), and it is referred to in the specifications of one German patent as suitable for this purpose, but it appears to offer no great advantage over other materials containing cellulose which can be so employed and which are obtainable in larger quantities at lower rates.

Some attention has recently been paid to the utilisation of "kapok" in France, and it is stated that it has been successfully employed in Bordeaux for the manufacture of a soft, non-conducting felt. Attempts have also been made to utilise the floss for the "nap" of silk hats, but no information is available to show that it has been employed on a commercial scale for this purpose.

Of the Indian flosses now under examination, only one—No. 19,397—was considered at all likely to be suitable for textile purposes, and it was submitted to an expert for technical trial. The expert reported that the floss was composed of straight, non-adherent fibres which were finer than those of good quality cotton, and that the material was too slippery and fluffy to be spun alone, but that it might be spun in admixture with cotton or wool, and that a fabric so prepared might for a time attract attention as a novelty.

As Upholstery Materials.—"Kapok" has come into use very largely in certain European countries in recent years, notably in Germany and Holland, as a material for stuffing cushions, pillows, chairs, bedding and similar articles. For such purposes, its non-hygroscopic character and its softness and resiliency render it peculiarly suitable. It is also stated to be less absorbent and less liable to harbour insect parasites than the materials generally employed in upholstery, and, according to the authorities of the Pasteur Institute in Paris, it can be sterilised by heat at least three times without being seriously damaged, whereas feathers and other upholstery materials do not usually survive this treatment more than twice.

The Indian flosses were, with the exception of No. 19,397, not

nearly so soft and resilient as Javanese "kapok." Attention has frequently been drawn to a similar defect in commercial Indian "kapok," and this has usually been regarded as being due to the material having been too highly compressed in order to lessen freight charges. In the present specimens, however, the inelastic character cannot be due to this cause, but has probably been produced by beating the floss in order to remove the seeds. In Java it is stated that a form of cotton gin has been successfully used for freeing the "kapok" from seeds, and doubtless the commercial value of these Indian flosses as upholstery materials would be enhanced if they were cleaned by such a process, instead of by the crude method of beating out the seeds now employed.

A number of other suggestions for the utilisation of "kapok" have been made at various times. Among these, reference may be made to the proposal to employ it as a surgical dressing, for which purpose, however, its slight absorptive power for aqueous liquids is a disadvantage. Recently it has also been used for the manufacture of buoys and life-belts. In this connection it may be mentioned that the statement has been made that several important lines of steamships have recently adopted "kapok" as a stuffing material for berth-mattresses, not only on account of its softness and resiliency, but also because of its buoyancy, the idea being that mattresses made of "kapok" could be used as temporary rafts or floats in emergencies.

It was impossible with the small quantities of these Indian flosses supplied to the Imperial Institute to make buoyancy experiments, but it may be mentioned that a few preliminary experiments of this kind have been made with the floss obtained from the seeds of *Funtumia elastica*, and it has been found that this material when merely packed in calico and placed in water will support a considerable weight for a day, without showing any noticeable increase in the extent to which it is submerged, and there is little doubt that the Indian flosses would behave similarly, so that it might be worth while to make further experiments to ascertain the suitability of these materials for the construction of life-belts, floats, etc.

The results of the investigation of these Indian flosses show that these products are on the whole inferior to the "kapok"

produced in Java, but that in view of some of the uses to which "kapok" and its substitutes are now being applied, it is quite likely that a market would be found for these Indian flosses at lower rates than those obtainable for the Javanese material. It must be remembered, however, that silk flosses of this kind are very widely distributed, and since attempts are being made at the present time to create an export trade in these products in South America and in various parts of Africa, notably Madagascar, the market is likely to be overstocked in the near future, and the prices realised for these materials will be small.

COTTON FROM BRITISH NEW GUINEA.

A SAMPLE of this cotton, accompanied by a specimen of its seed, was forwarded to the Imperial Institute by the Administrator of British New Guinea, who asked for a report on the commercial value of the cotton, which was stated to grow wild in the northern parts of British New Guinea.

The additional information was given that the native name of the cotton was "Goto," and that it was not used for any purpose, but was occasionally attached in small bunches by the natives to their spears as a decoration.

The sample, which consisted of one pound of ginned cotton, has been examined in the Scientific and Technical Department of the Imperial Institute, and has been referred to commercial experts for valuation.

The cotton was clean, of a pale cream colour, with occasional brown and dark-grey stains, and of bright appearance but not silky. The staple was coarse, harsh to the touch, wavy, of average strength, and of somewhat irregular length varying from 1·1 to 1·7 inches. The cotton had a neglected appearance, and contained some portions which had been gathered while immature and other portions which had been left too long in the boll, and consequently had become weather-beaten and stained.

The seeds were dark-brown in colour, smooth, and attached to one another in groups of from six to ten; from the form and appearance of these groups the product is known as "kidney cotton."

The commercial experts reported that the staple was long, strong, hard, and very coarse, and that the sample contained some dead cotton, *i.e.* immature fibres which are incapable of retaining dyes. The value of the cotton was estimated at about $4\frac{1}{2}d.$ per pound, "Middling American" being worth $4\frac{1}{2}d.$ per pound on the same date.

From the foregoing account it is evident that the material is of good commercial value, and that since the cotton is of good length and colour when grown wild, it would no doubt repay careful cultivation. The value of the cotton could be considerably enhanced by this means, and especially by the adoption of systematic methods of harvesting.

MUSA FIBRES FROM EAST AFRICA.

ATTEMPTS have been made during recent years in German East Africa to utilise two species of Musa, *M. Ensete* and *M. ulugurensis*, for the production of fibres, and, in view of the interest which this subject might have for planters in the adjacent British Protectorates, samples of these fibres have been examined at the Imperial Institute. The specimens were supplied through the Foreign Office and H.M. Consul at Zanzibar, by Professor Zimmermann, Director of the Biological and Agricultural Institute at Amani, who also furnished the following particulars regarding the fibres.

The fibres are prepared by the natives in a very primitive manner, but samples from each species which were forwarded to Germany in 1903 were reported by experts to be of very good quality, though inferior to true Manila hemp. The plants do not produce suckers, and therefore can only be propagated from the seeds, which in both cases germinate fairly easily. The yield of fibre from *Musa ulugurensis* is small in comparison with that from *Musa textilis*, the Manila hemp plant, but it is possible that this disadvantage may be compensated by the more rapid growth of the former plant, and by cheaper labour and improved methods of fibre extraction.

The samples of fibre have been examined in the Scientific and Technical Department of the Imperial Institute, and have been submitted to commercial experts for valuation.

Description of Samples.

The samples of *Musa Ensete* fibre were of two qualities. The sample marked "first quality" consisted of about half-a-pound of nearly white or pale straw-coloured fibre, which was of lustrous appearance and good strength and had been well prepared. The length of staple was 5½ to 6 feet.

The sample marked "second quality" weighed about half-a-pound, was of a darker colour than the previous sample and slightly inferior in strength. The staple was from 4 to 4½ feet long.

The sample of *Musa ulugurensis* fibre weighed four pounds, and resembled the *Musa Ensete* fibre in appearance, but was less lustrous and harsher to the touch.

Chemical Examination.

The results of the chemical examination of these samples of fibre are given in the following table. There are no results of any previous investigation of these fibres available for comparison, for although *Musa Ensete* grows in Jamaica, and some experiments on the extraction of the fibre were carried out many years ago, no chemical examination was recorded.

	Musa Ensete.		*Musa ulugurensis.*
	1st Quality. Per cent.	2nd Quality. Per cent.	Per cent.
Moisture	9·7	9·4	10·2
Ash	1·5	1·7	1·6
α-Hydrolysis, loss	10·3	13·0	22·9
β-Hydrolysis, loss	15·1	18·3	24·7
Mercerisation, loss	11·0	12·7	17·9
Acid purification, loss	0·8	3·7	6·5
Nitration, gain	36·5	26·3	37·4
Cellulose	78·1	74·5	70·7
Length of ultimate fibre	2·6 – 5·9 mm. (0·10 – 0·23 in.) Average length 3·8 mm. (0·15 in.)		2·2 – 4·7 mm. (0·08 – 0·18 in.) Average length, 3·1 mm. (0·12 in.)

These figures show that the samples of *Musa Ensete* fibre are rich in cellulose, fairly resistant to the action of alkali—as shown by the results of hydrolysis and mercerisation—and contain but a small proportion of adventitious impurity, as indicated by the results of the ash and acid purification determinations. In all these respects the sample marked "first quality" is

superior to that marked "second quality." The fibre is doubtless of considerable value and would probably prove a very durable material.

The results also demonstrate that the sample of *Musa ulugurensis* fibre is decidedly inferior to those of *Musa Ensete* in all the points referred to above, and would consequently be less durable.

Commercial Valuation.

The commercial experts to whom the fibres were submitted reported that they were of very promising quality. The "first quality" of *Musa Ensete* was stated to be of good bright colour, well cleaned, readily saleable in the London market and probably worth about £50 per ton. The "second quality" was considered to be inferior in colour but of good quality, and worth £45 per ton. The fibre of *Musa ulugurensis* was regarded as a very useful material but inferior to that of *Musa Ensete;* its value was estimated at £40 per ton. These valuations are based on the expectation that no special difficulty will be encountered when the fibres are worked by machinery in manufacturing processes.

The results of this investigation have shown that these East African *Musa* plants would no doubt prove well worth cultivating for the sake of their fibre, which, if carefully prepared, would obtain a ready sale at good prices. It has been stated in the Official Report on the British East Africa Protectorate for 1903–1904 (Cd. 2331), that a wild banana plant which produces an excellent fibre grows in several districts of the Protectorate. It is possible that this plant may be one of the species of *Musa* referred to above. Steps have been taken to identify the plant and prepare samples of its fibre for examination at the Imperial Institute.

PATCHOULI AND CITRONELLA OILS FROM PERAK, FEDERATED MALAY STATES.

THESE two samples of volatile oils were forwarded to the Imperial Institute from Perak, at the suggestion of the Superintendent of the Botanic Gardens, Singapore, and it was requested that they might be examined and their quality and commercial value ascertained.

CITRONELLA OIL.

Description of Sample.

The sample measured about four fluid ounces. The oil was of a pale yellow colour and possessed the characteristic fragrant odour of citronellal; it was quite clear and free from water.

Chemical Examination.

The oil was examined in the Scientific and Technical Department of the Imperial Institute, and gave the results recorded in the following table, which also contains, for convenience of comparison, the average results obtained in the analysis of other citronella oils of commerce.

	Sample from Perak.	Java oil.	Ceylon oil.
Specific gravity	0·8948 at 15°C.	0·892	0·908
Refractive index	1·4858 at 24°C.	—	—
Optical rotation in 100 mm. tube	− 1°34′ at 24°C.	− 0°50′ to − 2°26′	− 9°36′
Solubility in 80 per cent. alcohol	1 in 1 or more vols. of alcohol	1 in 1 or more vols. of alcohol	1 in 1 vol., becoming cloudy on further addition of alcohol.
Geraniol	32·7 per cent.	31·9 to 38·1 per cent.	32·9 per cent.
Citronellal (by difference) .	55·3 per cent.	50·4 to 55·3 per cent.	28·2 per cent.

These results show that this sample of citronella oil from Perak is of good quality, and that in composition it more nearly approximates to Java oil than to that produced in Ceylon.

Commercial Valuation.

A sample of the oil was submitted for valuation to a firm of commercial experts, who were also informed of the results of the chemical examination. They reported that the oil was very similar to samples of the same material previously received from Singapore, and that it would be worth about two shillings per pound. On the same day Ceylon citronella oil was quoted at 1*s*. 6½*d*. to 1*s*. 7*d*. per pound.

PATCHOULI OIL.

Description of Sample.

The sample measured about four fluid ounces. The oil was of a dark lemon yellow colour and possessed the characteristic strong persistent odour of patchouli.

Chemical Examination.

The sample was examined in the Scientific and Technical Department of the Imperial Institute and gave the results recorded in the following table, to which have been added the results given by other samples of commercial patchouli oil :—

	Oil from Perak.	Oil imported from Singapore.	Oil distilled from patchouli leaves in Germany.
Specific gravity	0·9525	0·957 to 0·965	0·970 to 0·995
Optical rotation in 100 mm. tube	$-43° 31'$	$-44°$ to $-50°$	$-50°$ to $-68°$
Refractive index	1·5063	—	—
Solubility in 90 per cent. alcohol	1 in 7·4 vols.	1 in from 3 to 7 vols.	1 in 1 vol.

These results indicate that this sample of patchouli oil from Perak is of fair quality, and that it conforms to the general type of patchouli oils exported from Singapore.

Commercial Valuation.

A small sample of the oil was submitted, together with the results of its chemical examination, to a firm of manufacturing perfumers for commercial valuation. It is reported that the oil would probably be worth about 16*s.* per pound at present. It is also stated that there has been a marked decrease in the consumption of patchouli oil in perfumery in recent years, and that this in conjunction with over-production in the Federated Malay States, Java and Indo-China, has led to low prices for this oil.

The results of the investigation of these two oils show that they are both of good quality and compare favourably in composition with oils of the same type already imported into this country, and that consignments would probably fetch good prices on the London market.

RUBBERS FURNISHED BY *ECDYSANTHERA MICRANTHA* AND *PARAMERIA PEDUNCULOSA* FROM BURMA.

THESE specimens of latex were collected at the instance of the Conservator of Forests, Tenasserim Circle, Rangoon, and were forwarded to the Imperial Institute for examination by

the Officiating Reporter on Economic Products to the Government of India. Only very small samples (one ounce phials) of the two latices were transmitted, and the amount of material was therefore insufficient for any extended investigation. The latex from *Parameria pedunculosa* had coagulated before the specimens were despatched from Rangoon.

ECDYSANTHERA MICRANTHA, A. DC.

This plant, known in Burma as "Nwedo," is a climber or vine and has only been definitely recognised as a source of rubber during the last two or three years. It is stated to occur in Assam, Burma, Siam, Southern China and French Indo-China, and in the last-named country it is exploited by the natives for its rubber. Some information concerning the vine and the native methods of preparing rubber from it has been published by the French officials, but no analyses of the product appear to have been made.

It was requested that the sample of latex should be examined in order to determine (1) the nature of the bitter principle which it is stated to contain, and (2) the best method of coagulating and preparing the rubber from it. The quantity of latex supplied was, however, too small to allow any experiments regarding the first point.

On arrival in this country, the sample had already undergone partial coagulation with the formation of a small quantity of rubber, and very little of the fluid latex remained for examination. Experiments with the small quantity available showed that the latex could be readily coagulated by the application of gentle heat, and this method could be easily employed for the preparation of the rubber upon a large scale. Care would have to be taken, of course, to avoid overheating the rubber, and in order to ensure this in practice it would be desirable to effect the coagulation by immersing the vessel containing the latex in boiling water. The rubber thus obtained should be well washed and pressed, and then dried in the shade as thoroughly as possible before shipment.

The rubber furnished by the spontaneous coagulation of the latex, together with that obtained on heating the residual liquid, was well pressed to remove as much moisture as possible, and

was then dried by exposure to the air upon a porous tile. After this treatment the total yield weighed 7·5 grams, about 25 per cent. of the weight of the original latex. Judged by its physical properties the rubber was of very fair quality, as it was free from stickiness and exhibited fairly good elasticity and tenacity.

The chemical examination of the dry material gave the following results :—

Caoutchouc	84·1 per cent.
Resin	11·5 „
Insoluble matter. . .	4·4 „
Ash (included in insoluble matter)	1·3 per cent.

This analysis shows that the rubber contained 84 per cent. of caoutchouc (true rubber), which was of very good quality, and 11·5 per cent. of resin, and confirms the opinion of its quality based upon its physical properties. The percentage of resin is rather higher than is desirable, but further analyses will be necessary before the above result can be accepted as representative.

PARAMERIA PEDUNCULOSA, BENTH.

This vine, known as "Kamanoo" in Burma, has also been described as *Ecdysanthera pedunculosa*, Miquel, and has been stated by van Romburgh to furnish good rubber in Java and Sumatra. No other experiments appear to have been made upon the vine.

The latex had completely solidified before being despatched from Burma, and was received here as a pinkish-white curdy substance, which, after drying on a porous plate, formed a friable powder. The material, therefore, possessed none of the physical properties of rubber, but softened and became adherent when placed in hot water.

The composition of the dry material was as follows :—

Resin	88·5 per cent.
Caoutchouc	10·7 „
Insoluble matter . . .	0·8 „
Ash (included in insoluble matter)	0·3 per cent.

The product is therefore of very resinous character, containing only 10·7 per cent. of caoutchouc, which, moreover, was sticky and of inferior quality. Material possessing this composition and character would have very little commercial value, but, in view of the favourable opinion which has been expressed regarding the product from this vine in Java and Sumatra, further investigation appears to be desirable.

Steps should be taken to confirm the identity of the vine, and further experiments made to determine the character of the product furnished by the latex. It is stated by the Conservator of Forests that the latex coagulates very shortly after collection, so that it cannot be strained in the factory to remove dirt. This could probably be prevented by diluting the latex with water at the time of collection and afterwards inducing coagulation, if this does not occur on standing, by gentle heat, as in the preceding case, or by the addition of a suitable chemical coagulant. Analyses of the samples thus obtained would enable the nature of the material to be definitely ascertained.

MONAZITIC SAND FROM QUEENSLAND.

A CONSIGNMENT of fine sand, weighing about one hundredweight, was forwarded for examination to the Imperial Institute by the Agent-General for Queensland, who stated that the material had been submitted by the Department of Mines of Queensland in order that its chemical composition might be determined, and the commercial value, if any, of the constituent minerals ascertained.

A preliminary examination of the material showed that it contained only a small proportion of heavy minerals likely to be of commercial value. The crude sand was, therefore, concentrated by the action of running water, and in this way a considerable amount of quartz, felspar, biotite-mica, actinolite and minute rock-fragments of no commercial value was removed, whilst a residue consisting principally of heavy minerals amounting to about 21 per cent. by weight of the whole was obtained.

This concentrated material was then analysed in the Scientific

and Technical Department of the Imperial Institute, and gave the following results:—

Silica, SiO_2	7·59	per cent.
Titanium oxide, TiO_2 . .	44·59	„
Zirconium oxide, ZrO_2 . .	1·06	„
Thorium oxide (thoria), ThO_2 .	0·23	„
Alumina, Al_2O_3	1·46	„
Yttria, Y_2O_3	0·10	„
Ferric oxide, Fe_2O_3 . . .	1·24	„
Ferrous oxide, FeO . . .	36·38	„
Manganous oxide, MnO . .	2·79	„
Copper oxide, CuO . . .	0·05	„
Lime, CaO.	0·79	„
Magnesia, MgO . . .	1·16	„
Cerous oxide, CeO . . .	0·46	„
Phosphoric acid, P_2O_5 . .	0·41	„
Niobic oxide, Nb_2O_5 / Tantalic oxide, Ta_2O_5 . .	0·78	„
Moisture	0·80	„

These results indicated the presence of the minerals ilmenite, quartz, garnet, zircon, magnetite, monazite, and possibly tantalite in the "concentrate," and this was confirmed by microscopical examination. The proximate composition of the concentrated mineral may, therefore, be taken as:—

Ilmenite (Fe, Mn, Mg)O, TiO_2 .	84·0	per cent.
Magnetite, Fe_3O_4 . . .	1·8	„
Zircon, ZrO_2, SiO_2 . . .	1·4	„
Quartz, SiO_2	4·4	„
Garnet and other silicates containing alumina, lime and magnesia	5·0	„
Monazite*	1·2	„
Tantalite	0·9	„
Moisture	0·8	„

The amount of thoria present in the "concentrate" is only 0·23 per cent., and in the crude mineral 0·05 per cent., and the proportion of cerium oxide 0·46 per cent. in the "concentrate," and 0·10 per cent. in the original sand.

* A portion of the thoria may be present as thorite (thorium silicate).

Material as poor in these oxides as the present sample, or even the "concentrate" prepared from it at the Imperial Institute, would probably not prove remunerative to work under present conditions. At the present time the value of the "concentrate" as a source of thoria would probably not exceed £2 10*s*. per ton, assuming that it would pay to extract thoria from such material.

The percentage of thoria could doubtless be increased by removing the magnetite and ilmenite by magnetic separators, but it would seem hopeless to attempt to compete by this means with the Brazilian monazitic sands which constitute at present the principal commercial source of thoria; these in the concentrated form in which they are exported yield about 4 per cent. of this oxide. Further, the new Ceylon mineral (thorianite) contains about 70 per cent. of thoria, and therefore is of greater value than any other source of thoria. (See this *Bulletin*, 1905, Vol. iii., p. 151.)

The percentage of cerium oxide in the Queensland sand is double that of the thorium oxide, but the demand for the former is very limited, since, in the construction of mantles for incandescent gas lighting, only one per cent. of ceria is used to about 99 per cent. of thoria.

Titanium oxide is present in the concentrate to the amount of 44·59 per cent. corresponding to 9·27 of the crude sands. Titanium is but little employed in the arts. It forms useful alloys with iron and steel and the carbide has been tried with some success in the manufacture of filaments for electric glow-lamps and the oxide for the preparation of mordants in dyeing leather. For the last-mentioned purpose, the present material could hardly be utilised. In 1902, a sample of titanium ore from Queensland was examined at the Imperial Institute, and found to contain 74·02 per cent. of titanium oxide, and 21·27 per cent. of ferrous oxide. It was submitted to two firms who are employed in the manufacture of titanium mordants to be used in leather dyeing. They reported that it was of no use for this purpose, on account of the high percentage of ferrous oxide it contained. If the ilmenite in the sand now in question were separated in a pure state, it would contain only 55 per cent. of titanium oxide, and 45 per cent. of iron and manganese oxides, so that it will be quite unsuitable for the manufacture of

mordants. The presence of these oxides would, however, be quite unobjectionable if the ilmenite were employed in the manufacture of titaniferous iron or steel, but at present this industry has hardly advanced beyond the experimental stage, and the employment of titanium carbide in electric glow-lamps is in much the same position. The demand for titanium oxide for these purposes is therefore still very restricted, and the supply of titanium ores is practically unlimited.

The only other constituent of the sand likely to possess commercial value is the tantalum. Recent experiments have shown that this metal can be used as a filament in electric glow-lamps, and such lamps are now on the market. The "concentrate" prepared from the Queensland sand contained, however, only 0·78 of tantalic and niobic oxides, so that it is improbable that this material could be used as a commercial source of tantalum in competition with the other richer tantalum minerals available.

No precise information was supplied with the consignment regarding the locality in which the sand was found, nor the conditions under which it occurs. It is impossible, therefore, to say whether by further search a richer sand is likely to be obtained, but it may be suggested that it would be worth while to continue explorations in the same district in the hope of securing richer material.

GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

ECONOMIC RESOURCES OF UGANDA.

WITH AN ACCOUNT OF THE BUDDU FOREST.

IN the first issue of the *Bulletin of the Imperial Institute* (Vol. i., 1903, p. 35), a short account was given of the establishment of the Botanic Gardens at Entebbe in the Uganda Protectorate and of the steps which were being taken to introduce new plants of economic value into the country. Since that date the work of the Scientific and Forestry Department of the Protectorate has considerably extended, and the report for the year 1904–5 by Mr. M. T. Dawe, the Officer in Charge, gives evidence of the progress which is being made. The Department

now has under its control the Botanic Gardens at Entebbe, the forestry service of the Protectorate, two experimental farms, eight meteorological and five hydrographical stations.

During the year under notice an important survey of the Mabira forest and of certain other districts was undertaken, and much valuable information was thereby collected regarding the indigenous economic products of the country (see this *Bulletin*, Vol. iii., 1905, p. 41). Two new species of Landolphia, which have been named *L. Dawei* and *L. ugandensis*, were found, and the first of these yields rubber of excellent quality.

It was also discovered that the well-known Lagos rubber tree, *Funtumia elastica*, is indigenous in the forests of Uganda. This tree had not previously been found so far east, and was commonly supposed to be restricted to western tropical Africa. The discovery is of the greatest importance, as the tree yields excellent rubber and is eminently suitable for systematic cultivation. Large quantities of seed have been collected and supplies have been distributed throughout the country with a view to the establishment of plantations of the trees.

The most important rubber vines which occur in Uganda are *Clitandra orientalis*, *Landolphia Dawei* and the well-known *Landolphia owariensis*. *Clitandra orientalis* occurs in nearly all the forests around the Victoria Nyanza and yields good rubber, a consignment having been sold in London at 4*s.* 9*d.* per lb. in November last. *Landolphia Dawei* is not so widely distributed as the above Clitandra and occurs most abundantly in the forests south of Buddu. It yields excellent rubber, samples of which were recently valued in London at from 4*s.* 4*d.* to 4*s.* 9*d.* per lb., the current price of fine Para being 5*s.* 1*d.* per lb.

With reference to the exotic rubber trees which have been introduced, it is stated that the Para trees (*Hevea brasiliensis*) did not make very satisfactory progress during the year owing to the growth being checked by a very severe hailstorm which inflicted considerable damage upon the young plants. Over 1,000 seedlings were ready for planting out this year as against 300 established during the previous year, but several years of further trial will be required in order to decide whether the Para tree can be successfully grown upon a large scale under the conditions which obtain in Uganda. The prospects of the Central American

tree (*Castilloa elastica*) are stated to be very favourable, as it is not so liable to injury from storms, and its growth is much more robust and rapid. About 600 seedlings of this species were available for planting out this year, and a number of young plants have been already distributed to several parts of the Protectorate for trial. The Ceara tree (*Manihot Glaziovii*) has not given very promising results, as some four year old plants which were tapped experimentally only yielded about ½ oz. of rubber per tree, and for the present it is not proposed to extend its cultivation.

Experiments are still in progress with tea, coffee, and cacao. Tea promises to do well in certain localities ; the trial plots at Masaka and Kakumiro have given very good results, but that on Sesse Island was completely destroyed by white ants. Coffee has been found to do extremely well in Uganda, and the experimental plantation of Nyasaland coffee yielded an average of 12 oz. of parchment coffee per tree as its maiden crop. Supplies of the seeds of this variety have been distributed to planters throughout the Protectorate. Several other varieties of coffee are also receiving experimental trial at Entebbe. The cacao trees have made little progress during the year, and show an undesirable tendency to branch from the base of the main stem, but the trees have commenced to fruit and a trial crop will soon be available.

The fibre trade of the Protectorate, which is principally confined to Sansevieria and Raphia fibres, is stated to be increasing annually, and experiments with other fibre-yielding plants, such as the Mauritius hemp (*Furcræa gigantea*), are in progress.

Experiments have been commenced with cotton, several varieties of which are undergoing trial, and the results already obtained indicate that American Upland cotton will probably be found more suitable for cultivation in Uganda than Egyptian varieties. Several tons of Egyptian seed—Mitafifi, Ashmouni, and Abassi—were distributed to planters and natives for trial, but the American Upland seems to do better than any of these and furnishes cotton of longer staple than in its native country. Arrangements are in progress to obtain trained pupils from the Indian Agricultural Colleges to instruct the natives in the proper methods of cotton cultivation, and it is hoped that this action

will induce the natives to grow cotton upon a considerable scale. During the last year it was estimated that the natives in the Uganda Province alone had about 360 acres under cotton.

A number of exotic fruit trees have been introduced into the country and most of these are making good progress, whilst a considerable number of flowering plants and shrubs have been added to the collection during the year.

The appendix to the report contains the meteorological statistics for the Protectorate during the year, as recorded at the eight stations, and also the levels of the Victoria and Albert Nyanzas and of the Nile at Wadelai and Gondokoro. The annual rainfall amounted to 63·01 inches at Entebbe (164 wet days) and 91·26 inches at Mbarara in Ankole; the daily mean sunshine at Entebbe was 5 hours 55 minutes, 3 minutes in excess of the daily mean of last year; and the maximum temperature varied at the different stations from 76·2° to 101° F. and the minimum from 50° to 60° F.

The following is a report on a journey recently made through the Buddu Forest of the Uganda Protectorate by Mr. M. T. Dawe, of the Scientific and Forestry Department.

The forests of the county of Buddu lie mainly along the coast of Lake Victoria Nyanza, and extend from Bujeju to Sango, a distance of about fifty miles. The country receding from this forest belt lies exceedingly low and swampy, and is but sparsely inhabited. Lying to the back of this flat the land becomes undulated, and is densely wooded in parts, small forests are here and there scattered in the valleys and along watercourses. The hillsides and valleys are very fertile, are cultivated, and densely populated.

The Bujeju forest consists of a long, somewhat narrow, and irregular belt, situated in the district known by that name, bounded on the east by the lake and on the west by the Duyu swamp. It covers about twenty square miles, and contains large areas of bush and grass land, so that actual forest would not amount to more than about fifteen square miles. For some distance the belt hugs the lake shore, while in some places a large sandy and marshy plain intercepts the forest and lake. The whole of Bujeju lies very low, many parts are only from twenty to fifty feet above the level of the lake. The Madzigo

plain, at a distance inland of five to six miles, is but fifty feet above the present level. It would seem that at a somewhat distant period, Lake Nabugabu and the marshy flat on either side were once part of the Victoria Lake. It is evident that the forest is a comparatively new one, and that it is gradually encroaching on its interior plains, for although now only bush land, it contains such kinds of trees that will eventually attain large dimensions and constitute forest land. The forest is not known to the natives by any one collective name; each part where intercepted by a grassy plain or garden, although connected in the main body, frequently bears a separate name. The most important sections are known from north to south as Misasa, Kyabizika, Kibudzi, Jubya, Galagala, Mabuywe, Mwenda, and Lugera. The latter is that section through which passes the Bujeju-Masaka road. Of forest trees there are not a great variety, the Mpewere (*Piptadenia africana*) and Musisi (*Coltis?*) constitute quite eighty per cent. of the whole. These are, in fact, the commonest trees throughout Buddu. Musisi is a tall tree growing to a height of eighty to ninety feet, with a girth of eight to ten feet. It yields a timber suitable for a variety of purposes, locally it is employed more particularly for canoes and house building. Amongst other trees in the forest the most conspicuous are—*Pycnanthus Schweinfurthii*, *Garcinia Buchanani ?*, *Trichilia emetica*, *Canarium Schweinfurthii*, and *Ficus sp.* The *Garcinia*, although a small tree, yields a serviceable timber, and a fruit fairly pleasant eating. The *Trichilia* is fairly common; it yields a first-class timber known as Enkoba; its seeds yield a useful oil or tallow. *Dolichandrone platycalyx*, the Lusambya, is occasionally met with, but is not common. A small sapotaceous tree (*Chrysophyllum ?*) yields a good timber, and is found throughout the forest. The fibre palm, *Raphia Monbuttorum*, occurs in the moist parts, and *Phœnix reclinata* is abundant. The bushland is largely composed of *Haronga madagascariensis*—an arborescent shrub which yields a kind of gamboge, acacias, *Zizyphus jujuba*, *Mussaenda arcuata*, *Carissa edulis*, *Uvaria sp.*, *Hugonia platysepala*, *Erythrina tomentosa*, etc. *Landolphia florida* and *L. ugandensis* occur in the forest, also *Funtumia latifolia*, but neither of these yield a serviceable rubber. It is rather strange that such a large belt of forest

should contain few or no good rubber-yielding vines, having Bunjiako on the north-east and the Mujuzi and Dumu forests on the south—both good rubber-producing areas. It is true a large bay about fifteen miles across separates Bunjiako from Bujeju, and that for some distance south the country is unsuitable for the growth of rubber vines. Bunjiako, however, is somewhat isolated, but contains abundance of good rubber—*Clitandra orientalis*, Stapf, and where the district is more or less connected with a rubber area, viz. the Mitalamarya forests, the vines are mainly of a different species known as *Landolphia Dawei*, Stapf. The soil throughout Bujeju is very arenaceous. A few attempts have been made in cotton cultivation, but the locality seems unsuited, the soil at certain periods being too moist. Several patches of cotton were attacked by a root fungus, which, no doubt, found in the moist soil conditions suitable to its growth and development. I have not noticed this disease in the hilly districts. The American varieties, especially the American Upland, thrive better here than the Egyptian kinds, and the lint of the latter is usually more or less discoloured. From Bujeju onwards along the coast the forest becomes more scattered, and is known as Lwamunda or Gwamba. It is bounded on the east by Lake Victoria, and on the west by Lake Nabugabu, and the sandy plain or swamp also known as Lwamunda; it extends to Namirembe, a harbour on the coast. The whole lies very low, and is at present submerged in many parts. Most of the forest is composed of a tree belonging to the order *Anonaceae*, known to the natives as Nsagalane. It attains a height of sixty to seventy feet, is not very large in girth, but yields a fair timber. The leaves, buds and fruit are very aromatic, and an unexpanded bud suggests a clove in appearance. Other common trees occur, but Nsagalane predominates. *Raphia Monbuttorum* is very abundant, and its fibre is being exploited by local firms. The belt is about ten or twelve miles long; it is difficult, however, to estimate the total area of the forest, being now submerged; several rapid streams draining the country around Lake Nabugabu flow into the Victoria Lake and render the country difficult to inspect. To the north of Lake Nabugabu about five miles west of Bujeju forest, beyond the sandy plain of Madzigo,

occurs an irregular belt of forest known as Kikondo; it extends beyond the camp Sunga, which is about nine miles inland from the coast. It contains all the trees common to the coast forest, towards which it extends in one direction; it also contains *Landolphia ugandensis*, but apparently none of the more valuable economic rubbers. The forest is marshy, and, including its branches and heavily wooded land, covers approximately two square miles. From this forest bearing south towards Kasaka the country is heavily wooded in parts, especially near the shores of Lake Nabugabu. A large stream flows into the lake here which drains the hills on the north-west. About two miles south of the village Kasaka, the country is densely wooded, and west of the swamp Lwamunda it merges into a small forest known as Kyatinda. It, however, contains only a few rubber vines and the trees common to Bujeju. From here towards the Catholic Mission Station of Narozari, small belts of forests occur all along the watercourses. Immediately at the back of Narozari hill, the forest is known as Nabitembi, so called because of the large number of wild bananas it contains. There are a few rubber vines in the forest, and it contains a large number of Musisi trees, and a fair number of Enkoba (*Trichilia emetica*). The area, including its small branches and adjoining belts, apparently known by a variety of names, is about 1¼ square miles. The country in this vicinity is thickly populated, and the soil is very fertile, much more so than near the coast. South-east of Narozari occurs Nabukongi forest; it covers an area of about three-quarters of a square mile, and contains little or no rubber. To the south-west of Narozari the country is heavily wooded, especially in the parts known as Naluambu and Sunga. Following the route of Nabukongi in a south-easterly direction, lies a forest known as Moao, which is really only separated from Nabukongi by a sandy plain. It contains a fair number of rubber vines of the kinds known as *Clitandra orientalis* and *Landolphia Dawei*, and extends along the southern portion of Lwamunda swamp to Namirembe, a harbour on the coast, and is not more than a square mile in area. Buye forest is part of the same belt, extending southwards, and is only separated from Moao by a footpath to Kagerira's from Namirembe. It contains a large number of rubber vines of both economic kinds. This forms part of the coast

forest, which extends all along from Bujeju to Sango, and which is really one unbroken but extremely irregular belt of forest, contiguous to and frequently merging inland into more or less sparsely wooded land. The contents of various parts of this belt, however, vary considerably, so that it would be advisable to continue to describe it by taking areas which are recognised by the natives as being distinct forests and which bear separate names, frequently after a stream, swamp or village. The areas given are only very approximate, for it would take months to get anything like an accurate estimate, owing to the irregularity of the forests, the difficulty in getting a good view overlooking them, and the frequent difference in native opinion as to their precise limitations. From Buye the forest is known as Kitabanaga; it lies along the lake, but is probably so called after the stream which rises in Kitabanaga swamp, and runs through the forest; it does not exceed one square mile in area. From here the forest is known as Nakigoe, a narrow belt, scarcely so large as Kitabanaga, but containing a fair amount of rubber. Proceeding southwards the forest is known as Mujuzi, and extends inland a distance of six to eight miles, following an irregular stream of the same name, which rises at the foot of Mitondo hill. The whole forest inland to the lake contains a large number of rubber vines, and, with wooded land, covers an area of four to five square miles. In addition to the trees common to the other forests, occurs a *Mimusops* and *Symphonia globulifera.* The latter is a West African tree which I had not before seen in Uganda; its timber is used for canoes, and its bark contains abundance of a gamboge-like substance common to most *Guttiferæ.* Another species of *Landolphia* is very common here, known to the natives as Kalakwa; it yields a pasty gutta-like substance with little or no elasticity, and is of no value. From Mujuzi southwards to the Kigona river, a distance more or less parallel to the coast of twelve to fifteen miles and extending inland about two miles, the forest is generally known as Dumu, and is leased for rubber as such, although in reality Dumu is a small village and harbour, and only the forest adjoining is known to the natives as Dumu. The most important branches, through nearly all of which streams of the same name flow, are known as Kinoni, Kilala, Korokoso, Kawasi, Kanroumi, Mugawo and

Kigona. They are all very rich in rubber of both economic species, and form one of the most valuable rubber-yielding areas within the Province of Uganda. Apart from these branches the forest is detached and scattered in many parts, consisting as it does all along from Bujeju of open plains, sandy swamps, and bushland. Some fine trees occur near the village of Dumu, a *Canarium* measured twenty-nine feet four inches in circumference at three feet from the ground. A fine tree known as Mumu, apparently *Sideroxylon brevipes*, yields an excellent timber, and grows from eighty to one hundred feet high, with a girth of twelve to thirteen feet. Another tree known as Nkobankoba produces a very serviceable timber; it is not, however, related to the Nkoba of Northern Buddu, which is *Trichilia emetica.* These streams that flow through the Dumu forest, which in dry seasons may be small, discharge large volumes of water into the lake during the rainy seasons, and at such times are not easy to cross away from the roads and bridges. The Kigona river was greatly swollen and difficult to cross, the water running high over the bridge. About a mile south of Dumu village near the Mugawe stream, occurs a coniferous tree, which for specific purposes yields one of the most valuable timbers of Uganda. It is a *Podocarpus.* Dr. Bagshawe, who made a collection of plants in Buddu a short time ago, intimated to me that he found a *Podocarpus.* I had, therefore, made special search for the tree, but it does not appear to grow north of the point mentioned. It occurs practically on the lake shore, a point of considerable importance respecting transport, and is distributed more or less throughout the forests down to the Kagera river, and it is said by the Baseba to extend beyond the Anglo-German boundary. The tree does not exceed about forty feet in height, but timber of good length can be cut from it, which is almost as easily worked as the Scandinavian timbers. Its insect resisting qualities are well known to the natives; instances have come to my notice where the poles have been taken inland a distance of ten to fifteen miles for building. A chief whose father had died and left a house built six years ago, is said to have rebuilt it with the same poles, which were as sound as ever. The young poles are very largely used for building purposes, and the result is that forests in thickly populated districts like Sango and Kanabulemu, do not

contain many large trees. The tree is known to the natives at Dumu as Mukeke, at Kanabulemu and Sango as Musenene, and to the Baseba as Muyunjui. It grows in swampy forests and could only be obtained in quantity during the dry season. Southwards from the Kigona river to Sango, the forest is very narrow and swampy and is known as Taro; it is at present inaccessible except in places from the lake side, the inland country being one vast expanse of low-lying marsh. From the Taro the forest recedes inland, being cut off from the lake by swamp, and is separated into more or less distinct forests. The one lying between Kanabulemu hill and the lake is known either as Namalala or Ntonju; it covers an area of eight to nine square miles, and is surrounded by swamp. These swampy forests appear to be entered by the natives very rarely except in the dry seasons. I noticed some of the chiefs who were building large houses, were sufficiently provident to get a good quantity of *Podocarpus* and other poles in the dry season that had passed. A thorough inspection of these forests can only be made in the dry seasons. The swamps surrounding them contain from two to four feet of water, and to obtain access to the forests is very difficult and unpleasant, for one must undergo the risk of occasionally disappearing up to the neck in water and bog. I entered this forest at one point only; it contains a valuable timber tree known as Nukunyun; it is a *Mimusops*, probably *M. cuneifolia*, and it is said by the natives to yield an edible fruit about the month of July. The handsome red-wooded lances that come from Bukoba are said to be made from this tree. It is one of the largest and commonest trees of these marshy forests. The *Podocarpus* also occurs, but being near Kanabulemu village, for reasons before mentioned, there are very few good trees. A fine *Baikaea* is found here; it is evidently the same species that occurs in Northern Buddu, but here grows much taller and straighter. Other trees found here are *Eugenia owariensis* and *E. cordata;* these are small trees, about forty feet high, and occur in all the forests of this part, the former frequently predominating. There are a fair number of vines of *Landolphia florida*, but none of the other rubber-yielding kinds were observed. Kasoli forest extends along the base of the hill on which stands the mission station Nazoretti. It is about six miles long and

averages about one-eighth of a mile in breadth ; it is only separated from Namalala by a swamp, and is of the same character. About four miles west or north-west of Taro and Namalala, across the flat near the Bukora river, there is a somewhat long belt of forest known as Byensansa ; it is at present inundated and inaccessible. I would, however, presume it contains much the same variety of trees as Namalala. Lying to the south of the Kanabulemu and Lusozi range of hills is an immense forest known as Luaja. It would appear from the Kanabulemu hill to be at least sixty square miles. It extends beyond the Kagera river into German territory, and scarcely half of the forest appears to be within the Uganda Protectorate. Unfortunately it is of the same swampy nature, and I spent one day only within its precincts. All of the trees found in Namalala occur in Luaja, and a *Croton*, evidently *C. zambesicus*. The tsetse fly is also present. In Sango, the hilly and rocky land lying between Kanabulemu and the lake, a few forests are found, distributed in the low-lying parts ; near Sango Bay, they are small clumps isolated in the swamps. I spent several hours wading up to the waist in water to reach one of them through about half-a-mile of swamp, and then found it composed entirely of *Eugenia owariensis*. Some of these trees were covered with a little black ant, which contributed by its bites in no little measure to enhance the unpleasantness of the situation. Between the lake and Misozi hill a belt of forest commences and extends along the shore to the Kagera river ; it is known in parts as Fubiro, Kakonda or Kitoma. It merges into very sparsely wooded land, which extends inland over a low-lying area of about twenty square miles ; actual forest land, however, would only be about two or two and a-half square miles. It contains in parts a fair number of rubber vines of the following kinds :—*Clitandra orientalis*, *Landolphia Dawei* and *L. ugandensis*. The trees are small and of dwarfish growth, the soil being poor and sandy. Amongst them are the *Baikaea* and *Podocarpus*. Near the Kagera river grows a little brilliant rosette-like parasite—*Thonningia sanguinea*, which I had previously only met with in the Mabira forest, Chagwe. Running almost parallel with the lake shore, about eight miles inland, lies another marshy forest. It appears to extend along a distance of about ten miles, and is about one-fifth of a mile in breadth. At

its north-western extremity near the foot of Lugere hill, it is fairly dry and contains a good number of rubber vines, but the remainder is swampy, and contains the trees common to Namalala. Across the Kagera river lies the Kaseba country; it is essentially pastoral, composed of grassy hills and plains. There are no forests, at least, not in the Uganda portion. From here I returned through Sango and Kanabulemu to Simba, and proceeded to Koki. At the base of the Koki hills, known as Nabunga, lies a small scattered forest near the Bukora river, known as Jengere. It is of the same character as the forests near Kanabulemu, and contains the same kinds of trees.

COTTON GROWING IN RHODESIA.

NUMEROUS experiments have been undertaken with the object of ascertaining the possibilities of growing cotton successfully in Rhodesia. Details of the various trials and accounts of the results obtained have been given from time to time in the Reports of the British South Africa Company and the *Rhodesian Agricultural Journal.*

The climatic conditions of Rhodesia are considered to be very favourable for cotton growing, and resemble those of the higher lands of Texas. It is necessary, however, that the cotton should be planted not later than the beginning of December, so that the crop may be gathered soon after the close of the summer rains, as otherwise it is liable to be injured by the frosts which occur in June.

The soil of Rhodesia is said to be, on the whole, well suited for cotton growing. The red soil appears to yield excellent results, and good yields have also been obtained from both the black and chocolate loams; on the other hand, the black clay is to be avoided, as it is liable to crack in the dry weather and cause injury to the roots of the plants.

A series of trials has been carried out at Mirongo and Katumbi. The seed was sown in December 1903, and January 1904. Two varieties were employed, viz. seed obtained from native cotton plants and imported Egyptian seed.

Seed of each variety was planted at Mirongo in a plot of black, rich soil, which was rather moist owing to its being situated at

the edge of a swamp. The Egyptian cotton grew well, and yielded a good crop, one plant bearing no less than 164 bolls; the plants did not appear to be injured by the cold.

The native or Senga cotton seed, which was purchased from the natives and sown in the same plot, germinated readily; the plants grew well, bore large numbers of flowers, and gave every prospect of a good yield of cotton. Unfortunately, however, the ripening was delayed by the cold weather, which caused considerable damage to the crop. The resulting cotton was pure white, soft, silky, and of good length. It was estimated that the yield would have amounted to about 500 lb. per acre if the cold weather had not interfered.

On another plot of ground in Mirongo, which was situated at the foot of a hill, both Egyptian and native Senga cotton were planted. The soil was black, and had a rocky sub-soil. The Egyptian cotton was successful, and yielded a crop of about 400 lb. per acre. The Senga cotton did not give a good result, the bolls falling from the plant before arriving at maturity, probably owing to the cold winds, the rocky nature of the subsoil, and also to the plants having been grown too close together.

Experiments have also been made at Mirongo to test the possibility of growing cotton as a perennial plant. Egyptian plants of two years' growth gave a crop of fairly good but rather short cotton, amounting to 500 lb. or 600 lb. per acre. Some native Senga cotton plants were left without attention and allowed to grow wild; these plants when seven years old yielded a large crop of cotton of good quality.

At Katumbi, Egyptian cotton seed was planted in dark, loamy soil. The plants grew to a height of 8 or 10 ft., but yielded a very small crop of cotton. Another experiment was made with Egyptian cotton at a distance of about half-a-mile from the Luumba River. The seed was sown in black, rich soil. The plants grew very well, attaining a height of 5–6 ft., and the bolls were large and full. The crop amounted to 400–450 lb. per acre.

The native Senga cotton was also found to flourish at Katumbi.

The results of these and numerous other experiments demonstrate that the prospects of cotton growing in Rhodesia are very

promising. If good seed is secured and careful methods of cultivation are employed, crops of 400–450 lb. per acre can be obtained. Many different varieties, including native, Egyptian, American, and Brazilian cotton have been tested, but apparently Egyptian cotton is best suited to the local conditions and yields the most satisfactory results.

Attempts are being made to persuade agriculturists to plant cotton, and also to induce the natives to take up the cultivation. Seed has been distributed to the natives, and assistance and advice are being given with regard to the cultivation. Some difficulty has been experienced with regard to the labour supply, but the opinion has been expressed that if the natives themselves can be induced to undertake cotton growing, the labour difficulty will be solved, since a native planter can always obtain plenty of assistance from neighbouring kraals.

The Rhodesian Cotton Syndicate, which was formed at the end of 1903, is at present carrying out extensive experiments with the aid of an American cotton specialist. There is no doubt that the country possesses large tracts of land well adapted for cotton cultivation, and in the Luangwa and Zambesi Valleys the rivers would afford transport facilities.

A number of samples of cotton grown in Rhodesia have been received at the Imperial Institute, and have been examined in the Scientific and Technical Department. Accounts of the quality and commercial value of these samples have been published in the *Imperial Institute Bulletin*, 1903, Vol. i., p. 123, and 1904, Vol. ii., p. 90.

An interesting series of cotton samples from Rhodesia, together with a map of the Colony showing the localities where cotton is grown were lent by the British South Africa Company for the recent Cotton Exhibition at the Imperial Institute. These samples attracted considerable attention, and the opinion was expressed repeatedly that the prospects of cotton growing in Rhodesia appeared to be very favourable if cotton of the quality shown could be produced on a commercial scale.

The first consignment of Rhodesian cotton for the British market has recently arrived in Liverpool. The cotton was grown from Egyptian seed and has been reported by experts as clean, fine, strong, and worth 6*d.* to 6¼*d.* per lb.

COTTON GROWING IN THE PORTUGUESE COLONIES.

THE cultivation of cotton in the Portuguese Colonies was first undertaken systematically in the year 1852, when special measures were initiated to stimulate the industry. These efforts were renewed on several occasions between 1852 and 1865.

In 1861 special concessions of land were granted in Angola and Mozambique for cotton cultivation, and a quantity of selected seed was imported from Brazil and the United States and distributed free to planters. In 1863, a Brazilian cotton expert was appointed to undertake the supervision of the plantations in Angola and to superintend the work of preparing the product for export. With the object of making the cotton known in the markets, the Portuguese Government allowed the colonial grown cotton to be exported free of duty for a certain period.

The first samples of the new cotton were received in Lisbon early in 1858, and were forwarded to Manchester, where the cotton was reported to be of first-class quality. The exports of this improved cotton (as distinguished from the native cotton) reached 10 tons in 1858 and rose rapidly to 300 tons in 1867, and 800 tons in 1877. The industry gradually declined, however, and in 1890 the amount exported had fallen to 200 tons, and during 1890–1892, little or no cotton was exported. In 1903, the exports amounted to about 17 tons, and in 1904 the quantity increased to 107 tons.

The planting of cotton has again been taken up both in Portuguese East and West Africa, and the advancement of the industry is receiving the attention of the Portuguese Industrial Association and the assistance and support of the Government. A Commission was appointed by the Government in the year 1904 to study the question, and its report was presented in March 1905.

The Commission made the following recommendations: Re-organisation of the Agricultural Departments of the Colonies to ensure the benefits of experimental guidance to agricultural enterprise; improvement of transport facilities, especially in the direction of utilising the African rivers; certain relaxations in the Customs tariff; measures to guard against the introduction

of pests with imported seed; and the encouragement of the natives to grow cotton.

In order to facilitate the export of cotton from West Africa, the Government propose to construct a railway, extending from Mossamedes on the coast to the Shella range.

In East Africa both the climate and the soil in the Provinces of Manica and Sofala are favourable to the cotton plant, and especially in the districts within thirty miles of the coast extending from the Zambesi to the 22nd parallel of latitude. The cultivation is being taken up with great prospects of success.

A series of cotton samples grown in the Portuguese Colonies was lent by the Portuguese Industrial Association for inclusion in the Cotton Exhibition which was held recently at the Imperial Institute (see this *Bulletin*, Vol. iii., 1905, p. 113). The Province of Angola was represented by several samples of American and Egyptian varieties which had been grown at Ambriz, Benguella, Loanda and Mossamedes. An interesting sample of a short-stapled variety of cotton grown in the Portuguese East Indies was shown which resembled Chinese cotton, and, like the latter, would no doubt be useful for spinning in conjunction with wool. The cotton growing industry of Mozambique was illustrated by samples of cotton of Egyptian "Mitafifi" and American varieties. Most of these samples were of good colour and promising quality.

THE CULTIVATION OF JUTE AND SIMILAR FIBRES.

JUTE is one of the cheapest fibres and is employed for making the coarse cloths used for sacks, bags, bale covers, and tarpaulins. At present, almost all the raw jute imported into the United Kingdom comes from Bengal. In the three years 1901, 1902, 1903 the average annual import was 325,000 tons; of this quantity, 319,000 tons, or 98 per cent. of the whole, came from Bengal. In recent years there has been a large increase in the machinery employed in India for jute spinning and weaving, and the export thence of "gunny" cloth, which is the name by which such coarse cloth is known in India, has risen from 307 million

yards in the year ending March 31, 1900, to 552 million yards in the year ending March 31, 1904. As a consequence of this, increasing quantities of jute are bought up in India, and the jute-spinners of the United Kingdom, whose mills are mostly situated at Dundee, experience a growing difficulty in obtaining the raw jute they require. To meet this emergency, the Jute Importers' Mutual Protection Association, Limited, of Dundee, is endeavouring to introduce the cultivation of this fibre into the West African Colonies, so as to have further areas to draw upon for supplies.

Jute is a "bast" fibre, that is a fibre found between the bark and the woody inner portion of the stem; it is derived from two species of plants, *Corchorus capsularis* and *Corchorus olitorius*, belonging to the natural order *Tiliaceæ*. The two species differ very little except in the shape of their fruit and no distinction is made in commerce between their fibres. Each of them possesses a white and a red variety of plant, and it is said that the fibre of the white variety of *C. capsularis* is the best. The jute plant is easily cultivated, it is an annual and grows to a height of 8 to 15 feet. It is ready for harvesting in about 3 or 4 months.

Climate.—Jute thrives best in the hot damp climates and moist districts of the tropical and sub-tropical zones. After it has made a good start, flooding of the land is not injurious, and it will even grow luxuriantly when half submerged in three feet or more of water. It is stated, however, that it is advantageous not to have too much actual rain, especially in the early part of the season, and that the best conditions are alternate sunshine and rain; excessive rain is not injurious after the plant has reached a height of several feet. Water standing at the roots or covering the land tends to produce suckers, and consequently less valuable fibre; on the other hand, drought stunts the plants and in dry districts the fibre is hard and stiff.

Soil.—Jute can be cultivated on almost any kind of soil; but lateritic and open gravelly soils and light sandy soils are unfavourable. Rich loams—that is, rich mixtures of clay and sand—seem the best, but it will also grow on clayey soils. In India the finer varieties are grown on the higher lands on which rice, pulses, vegetables, and tobacco are grown; the coarser and larger varieties are grown on alluvial deposits and islands formed

by the rivers, and also on the low lands liable to inundation. It also grows on the salt-impregnated soil of the Sunderbans.

Cultivation.—The soil is broken up thoroughly and finely pulverised, heavy or clayey soils require more ploughing than lighter or alluvial soils; the more thorough the ploughing the better the yield. In India 4 to 12 ploughings are given with the primitive ploughs of the country, and at the last ploughing all weeds are collected, dried and burnt. The land is sometimes hoed instead of ploughed. The soil is also harrowed or the clods are broken up with a mattock. Manures are sometimes used when the seed is sown early. Jute is rather an exhausting crop for the soil; but on the low lands this is immaterial and on the high lands the exhaustion can be remedied by manuring, by fallowing, or by rotation, the other crops in this case being mustard, rice, and pulses. The manures used are cow-dung, oil-cake, rice-crop stubble and ashes. The seed is sown from the middle of March to the end of June; 14 to 16 lb. of seed are used per acre, but as much as 30 lb. per acre has been recommended. The seeds are sown broadcast on a clear sunny day, the soil having been sufficiently moistened by rain, and are then covered with a thin layer of earth either by hand or by harrowing or by drawing a wooden beam over the field. They must neither be ploughed in nor left on the surface uncovered by earth. The seed is obtained from a few plants allowed to mature the previous year in a corner of the field; but the selection of good seed for planting is a matter that should receive attention.

When the plants have grown several inches or a foot high some weeding and thinning are done, and the weaker plants are removed where there is overcrowding. Weaklings are replaced by plants from places too thickly sown. The space between the plants is ordinarily 6 inches, but it is sometimes 8 to 10 inches. The plants mature in 3 or 4 months, so that the harvest of that sown in March will come in June, and of that sown in June will come in September or October. In India the best time for cutting the crop is considered to be when it is in flower and just before the appearance of the pods; at this period the fibre obtained is of superior quality. Fibre from plants that have not flowered is weak, whilst that from plants in seed is

harsh and deficient in gloss. Late cutting gives a woody and inferior fibre.

The plant is usually harvested by cutting near the root with a bill-hook or sickle ; when the land is under water, boys dive with a sickle to cut the crop and the retting heap is built upon the spot. On swampy and submerged land the crop instead of being cut is sometimes pulled up. The stalks are made into bundles each containing as much as a man can carry ; the tops are sometimes clipped off, and the leaves are sometimes removed before retting and sometimes are left on.

Retting.—The fibre is next separated from the stems by retting, that is by keeping them immersed in water until they partially decay, so that the fibre can be easily separated from the outer bark and the inner stem. In some districts the crop is stacked for two or three days before retting, in others the stalks are made into bundles and immersed in water immediately after reaping. They are sometimes immersed in running water, but more often in stagnant ponds ; the former plan is said to give the best fibre, especially as regards colour. The bundles are covered with a layer of refuse tops of the jute or of other plants, or with clods of earth or logs of wood in order to make them sink ; possibly stones might be preferable to earth as being less likely to injure the colour. It is stated that the stems should be covered so as to be protected from direct sunshine. In some places the bundles are turned over during the steeping.

The time required for satisfactory retting varies with the age of the plants, the temperature of the water, and with other conditions, and lasts from 2 to 25 days ; after the right point is reached further retting is injurious to the fibre, so the pools must be visited daily and the condition of the stems examined to see whether the fibre separates properly from the stem. When the retting is far enough advanced the bundle is unfastened, and the cultivator, standing up to his waist in the water, having first removed adventitious roots, loosens portions of the fibre at the end of the stems, and grasping these he strips off the whole with a little management from end to end without breaking either stem or fibre. When a certain amount of fibre has been stripped off, he next washes it by taking a large handful, swinging it round his head and dashing it repeatedly on the surface of the

water, and drawing it through the water so as to wash off the bark ; then with a dexterous throw he spreads it out on the surface of the water and carefully picks off the remaining black spots. It is then wrung out so as to remove as much water as possible and hung on lines to dry. It is said that jute dried in the shade retains a better colour than that dried in the sun.

The operations vary somewhat in different localities ; the fibre is sometimes first loosened by means of a wooden beater before separating it from the stem, and a thick plank or heavy piece of wood held firmly in position by posts driven into the bed of the pond is recommended as facilitating the washing process, by offering something more resisting than water to dash the root-ends of the plant against, these being less perfectly softened by the retting than the upper parts.

These primitive methods yield an exceptionally pure product, and the retting accomplishes the disintegration of the bundle of bast fibres. The process has not yet been superseded by machinery. The average yield is a little over 1200 lb. per acre, but it is sometimes double this quantity.

When thoroughly dry the jute is made up in bunches of as much as can be conveniently held in one hand ; these are doubled in the centre and taken in bundles to the market ; here they are sorted according to quality and colour, and then packed in bales for export. In Calcutta the bales are made by means of hydraulic presses, and weigh from 300 lb. to 400 lb.

The Prospects of Jute-growing in West Africa.

With reference to the cultivation of jute in West Africa, it may be mentioned that the true jute plant is stated to have been found there, and certain similar fibres are prepared and utilised by the natives. There is considerable uncertainty, however, as to whether the fibre collected by the natives is derived from the true jute plant, a large sample of fibre sent home having proved to be of a different nature.

From the facility with which the jute plant is cultivated and its fibre extracted, it seems very probable that numerous localities may be found in West Africa suitable for its cultivation, or

of native plants yielding a similar fibre, and that the natives will be able to acquire the method of preparing the fibre for the market. This crop will not prove a rival to cotton, since it can be grown on land quite unfitted for the cotton plant.

The rainfall of the jute-growing districts of Bengal ranges from 50 to 100 inches per annum, in some places rising to 130 inches; most of the rain falls in the months April to October. In Freetown, Sierra Leone, the rainfall is 170 inches per annum, May to October being the wet months. In Lagos the average annual rainfall is about 60 inches, April to November, but excluding August, being the wet months; thus the climatic conditions seem likely to suit the growth of the plant. A trial of jute-growing was made in Gambia in 1897, and the fibre produced was strong, of good spinning properties, very well prepared, and was classed as being of medium quality and quite merchantable; the length was short owing to the season having been dry (*Kew Bulletin*, 1898, pp. 38–40). Gambia has a lower rainfall (about 50 inches per annum) and a shorter rainy season—namely, from the middle of June to the middle of October—than Sierra Leone, so the latter is more likely to be favourable for jute.

Three small samples of fibre resembling jute from Sierra Leone have been examined recently in the Scientific and Technical Department of the Imperial Institute, and have been referred to experts for commercial valuation. The plants from which these products were obtained are said to occur in all parts of the Protectorate.

Sample No. 1 consisted of a small quantity of fibre which was of a pale straw colour, well cleaned and lustrous, and about 5 ft. 4 in. long. This product was stated to be known in the Mendi language as "Corwey," and was supposed to be derived from *Corchorus olitorius*.*

Sample No. 2 was brown in colour, well cleaned, silky, lustrous, varied in length from 5 feet to 7 feet, and was alluded to as the product of *Corchorus capsularis*.*

Sample No. 3 consisted of a fibre which is known to the natives of Sierra Leone as "Aukraw" fibre, and is derived from

* There is some uncertainty as to the accuracy of these identifications, and the question is being further investigated.

a plant the leaves of which are edible and employed for making native sauce. From this description and the appearance of the sample it appears probable that the plant yielding the fibre is *Hibiscus esculentus.* The material was of a pale straw colour, fairly lustrous but not well cleaned, was harsher to the touch than samples 1 and 2, and had a length of staple of about 3½ to 4 feet.

The samples were examined chemically as completely as was possible with the very small quantities available. The results are given in the following table, to which are added for convenience of comparison the results obtained with standard Indian jutes which have been examined in the Scientific and Technical Department of the Imperial Institute.

	1	2	3	Indian Jute. "Extra Quality."	Indian Jute. "Extra fine Quality."
Moisture, per cent. . . .	10·4	10·3	10·5	11·1	9·6
Ash ,, . . .	0·50	0·28	1·1	1·0	0·7
α-Hydrolysis, loss per cent.	6·8	6·8	13·4	8·5	9·1
β-Hydrolysis, ,, ,,	10·9	10·0	17·7	12·5	13·1
Cellulose, per cent. . .	78·8	77·1	77·2	79·0	77·7
Length of the ultimate fibres	1·6 – 2·7 mm. or 0·06 – 0·11 inch.	2·1 – 3·7 mm. or 0·08 – 0·14 inch.	1·2 – 3·1 mm. or 0·05 – 0·12 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.	

These figures indicate that all the samples are of good quality. In some respects No. 1 is the best, especially in its richness in cellulose and its resistance to the attack of alkali, as shown by the comparatively small loss on hydrolysis. It is evident that this fibre compares very favourably with the standard Indian jutes.

Sample No. 2 also resembles Indian jute in both chemical and mechanical properties.

Sample No. 3 is of a somewhat different character to the other samples, and is much more susceptible to the attack of alkali (as shown by the hydrolysis), and on this account would probably be somewhat less durable.

The commercial experts reported that samples No. 1 and 2 resemble Indian jute in their general character, but are not quite the same in all respects. Both samples are of good colour, and fair length and strength, but differ in sample No. 1 being harsher than No. 2. These fibres can be spun with good results when

mixed with jute, and would readily find a market at prices rather lower than the current rate for Indian jute. Similar samples have been recently submitted to spinning trials, and the present value is given as from £16 to £16 10*s.* per ton in Dundee, the price of jute being from £16 to £25 per ton, depending on the quality.

Sample No. 3 was reported to be of similar quality, but apparently not quite so strong as samples 1 and 2. If of somewhat greater strength it would be worth from £18 to £20 per ton, and would no doubt find a ready sale.

It is evident from the results of this enquiry that Sierra Leone is capable of growing fibre of good quality and possessing the characters of jute, though probably furnished by distinct plants. In view of the cultivation being started on a commercial scale, it is important that the variety of seed to be sown should be carefully chosen, and that, if different qualities of fibre are obtained, the various grades should be kept separate. Certain native plants may prove to be better worth extensive cultivation than Indian jute.

Jute Substitutes.

In order to overcome the difficulties occasioned by the deficiency in the jute supply, it is important not only to increase the area devoted to the cultivation of the jute plant, but also to ascertain whether the needs of manufacturers could not be met to some extent by other fibres. There are many plants which yield fibres resembling jute which would probably be found to possess the required properties. Among these plants may be mentioned species of Abroma, Abutilon, Hibiscus, Honckenya, Malachra, Sida and Urena.

Abroma augusta.—This plant is a small tree of the natural order *Sterculiaceæ*, which grows in the hotter parts of India and is said to be easily cultivated. Samples of the fibre were examined some years ago in the Scientific and Technical Department of the Imperial Institute, and were found to possess excellent qualities. In the following table the results of the chemical examination of samples of the fibre taken from young and old plants respectively are compared with those of a sample of Indian jute of "extra fine quality."

	Abroma augusta from young plant.	*Abroma augusta* from old plant.	Indian Jute. "Extra fine quality."
Moisture, per cent.	11·8	9·4	9·6
Ash, per cent.	0·6	0·6	0·7
α-Hydrolysis, loss per cent.	7·7	11·4	9·1
β-Hydrolysis, " "	13·9	16·6	13·1
Acid Purification " "	0·7	2·4	2·0
Cellulose, per cent.	78·0	75·5	77·7
Length of ultimate fibre	3 mm. or 0·12 inch.	4·0 – 6·4 mm. or 0·16 – 0·26 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.
Length of staple	4 to 8 feet.		Usual jute samples, 6 to 8 feet.

These figures show that the fibre of *Abroma augusta* resembles jute in its chemical behaviour and composition and has the advantage of possessing somewhat longer ultimate fibres. The fibre obtained from the young plants has a larger percentage of cellulose than that from the old plants, but microscopically the ultimate fibres were found to be rather thin and ill-formed. In the older plants these ultimate fibres improve both in length and substance, but the percentage of cellulose decreases, the fibre becomes harsher and coarser and also suffers greater loss in weight by the hydrolytic action of alkali.

Abutilon species.—Abutilon avicennæ, the Indian mallow, is cultivated on a commercial scale in China, and the fibre, which is said to be strong and lustrous, is exported under the name of Chinese jute. *Abutilon periplocifolium* (syn. *Wissadula rostrata*), a species which occurs in tropical America, also yields a fibre of good quality which is said to be of a type to compete with jute. It is possible that the fibres of other species of Abutilon would also prove suitable substitutes for jute. Samples of *Abutilon asiaticum* and *A. graveolens* from the Indian Collections of the Imperial Institute have been examined in the Scientific and Technical Department with the results which are given in the following table.

	Abutilon asiaticum from Kashmir State.	*Abutilon graveolens* from Madras.	Indian Jute "Extra fine quality."
Moisture, per cent.	10·3	7·0	9·6
Ash, per cent.	3·3	0·9	0·7
α-Hydrolysis, loss per cent.	13·3	10·2	9·1
β-Hydrolysis, " "	19·9	12·7	13·1
Acid Purification " "	4·2	6·2	2·0
Cellulose, per cent.	72·4	70·2	77·7
Length of ultimate fibre	1 – 4 mm. or 0·04 – 0·16 inch.	1 – 3·5 mm. or 0·04 – 0·14 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.
Length of staple	3 feet 6 inches.	About 3 feet.	Usual jute samples, 6 to 8 feet.

T

These results indicate that neither of these samples is of such good quality as that of the Indian jute, the inferiority being especially noticeable in the lower percentage of cellulose. The proportion of cellulose in the poorer qualities of jute, however, is not uncommonly as low as 70 per cent., and it is possible therefore that these *Abutilon* fibres might be useful for mixing with jute. Moreover, it appears not improbable that better specimens of these fibres might be obtainable, the sample of *Abutilon asiaticum*, in particular, not having been very well cleaned.

Hibiscus species.—Many species of *Hibiscus* (natural order, *Malvaceæ*) yield excellent fibres which would probably prove to be suitable substitutes for jute. A product which is derived from a plant either identical with or closely allied to *Hibiscus cannabinus* is exported from India and appears in the London market under the name of "Bimlipatam jute." Samples of this material have been examined in the Scientific and Technical Department of the Imperial Institute, and compared with an authentic sample of *Hibiscus cannabinus* fibre from Madras and also with an average sample of Calcutta jute. The results are quoted below.

	Hibiscus cannabinus from Madras.	"Bimlipatam Jute."	Calcutta Jute.
Moisture, per cent. . .	10·1	12·5	12·0
Ash, per cent. . . .	2·0	1·3	1·0
α-Hydrolysis, loss per cent.	8·8	11·8	9·2
β-Hydrolysis, ,, ,,	13·7	15·1	14·3
Acid Purification ,, ,,	2·5	1·0	2·6
Cellulose, per cent. . . .	74·8	75·4	76·4
Length of ultimate fibre	1·5 – 4 mm. or 0·06 – 0·16 inch.	1 – 4 mm. or 0·04 – 0·16 inch.	1·5 – 4 mm. or 0·06 – 0·16 inch.
Length of staple	7 feet.	7 feet.	8 feet.

These figures show that in composition and properties Bimlipatam jute is closely related to the fibre of *Hibiscus cannabinus* and that they both resemble ordinary jute. The percentage of cellulose is nearly the same in all three specimens, and the differences exhibited are probably attributable to differences in the age of the fibres and in the methods of preparation employed. In view of these results and the external resemblance of Bimlipatam jute to the fibre of *Hibiscus cannabinus* there can be little doubt that the products are identical.

The fibres of other species of *Hibiscus*, namely, *H. Abelmoschus*,

H. heterophyllus and *H. Sabdariffa*, have also been examined at the Imperial Institute, and have been found to possess characters resembling those of jute.

Honckenya ficifolia.—Some years ago, a sample of the fibre of *Honckenya ficifolia*, a plant of the natural order *Tiliaceæ*, was forwarded to this country from Lagos under the name of "Bolobolo" fibre, and was found to be a valuable product of the jute class. A report on this material was published in the *Kew Bulletin*, 1889, pp. 15–16.

Malachra capitata.—This plant is a shrub of the natural order *Malvaceæ* which occurs in India, tropical America and other countries. An Indian sample of the fibre has been examined in the Scientific and Technical Department of the Imperial Institute, and has been found to be little inferior to average samples of jute, whilst it has the advantage of a longer ultimate fibre.

	Malachra capitata.	Indian Jute. "Extra fine quality."
Moisture, per cent.	12·5	9·6
Ash, per cent.	1·0	0·7
α-Hydrolysis, loss per cent.	12·3	9·1
β-Hydrolysis, ,, ,,	17·8	13·1
Acid Purification, ,, ,,	2·6	2·0
Cellulose, per cent.	74·2	77·7
Length of ultimate fibre	4·0 – 6·0 mm. or 0·16 – 0·24 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.
Length of staple	6 feet.	Usual jute samples, 6 to 8 feet.

These results show that the fibre resembles jute, although the present sample is somewhat inferior to the Indian jute of "extra fine quality." This is apparent in the greater loss sustained on boiling with weak alkali (α- and β-hydrolysis) and also in the smaller proportion of cellulose present.

Sida species.—The fibre of *Sida rhombifolia* (natural order, *Malvaceæ*) is similar to jute in structure and general properties. Samples of this fibre and also of those of *S. carpinifolia* and *S. cordifolia* from India have been examined in the Scientific and Technical Department of the Imperial Institute and compared with jute.

The results are contrasted with one another in the following table.

	Sida rhombifolia from Rahuta, Bengal.	*Sida carpinifolia* from Madras.	*Sida cordifolia* from the Punjab.	Indian Jute. "Extra fine quality."
Moisture, per cent. . .	12·7	11·2	12·7	9·6
Ash, per cent.	1·6	1·8	1·5	0·7
α-Hydrolysis, loss per cent.	8·7	8·5	10·8	9·1
β-Hydrolysis, ,, ,,	14·5	14·5	14·5	13·1
Acid Purification ,, ,,	1·9	3·3	1·9	2·0
Cellulose, per cent. . .	79·3	78·8	78·5	77·7
Length of ultimate fibre	2 – 2·5 mm. or 0·08 – 0·10 inch.	1·5 – 2·5 mm. or 0·06 – 0·10 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.

These figures show that these fibres very closely resemble jute in chemical composition and behaviour and are somewhat superior in their richness in cellulose.

Urena lobata.—This plant is also a member of the natural order *Malvaceæ* and occurs in India, the United States, South America, Africa and other tropical countries. The fibre would probably be a good jute substitute. An Indian sample has been examined in the Scientific and Technical Department of the Imperial Institute and an investigation has also been made of specimens from Brazil, where it is known as "Aramina" fibre. The results are given below, and show clearly that this fibre is of the jute type and is very similar to jute itself in composition and properties.

	Urena lobata from India.	"Aramina" fibre from Brazil.	Indian Jute. "Extra fine quality."
Moisture, per cent.	9·9	9·3	9·6
Ash, per cent.	2·4	0·7	0·7
α-Hydrolysis, loss per cent.	12·2	10·2	9·1
β-Hydrolysis, ,, ,,	16·3	18·2	13·1
Acid Purification ,, ,,	3·0	1·9	2·0
Cellulose, per cent. . .	73·5	76·0	77·7
Length of ultimate fibre .	2·2 – 5·0 mm. or 0·09 – 0·2 inch.	1·5 – 3·5 mm. or 0·06 – 0·14 inch.	1·5 – 3·0 mm. or 0·06 – 0·12 inch.

THE MANUFACTURE AND USES OF WOOD-PULP.

THE production of wood-pulp for use in the manufacture of paper has attained enormous proportions during recent years, and the extent of the trade in this product is illustrated by the fact that during 1903 Great Britain alone imported 576,153 tons valued at £2,506,583. A review of the present position of the wood-pulp industry has been furnished recently by Mr. S. C.

Phillips in a paper read before the Society of Arts (see *Journal of the Society of Arts*, liii. 700), and a short summary of the chief points will be of general interest.

Our supplies of wood-pulp, in its various forms, are principally derived at the present time from Scandinavia, where enormous forests of suitable timber are available, and during 1903 the imports into this country from the above source amounted to 480,481 tons. The permanence of the output from Scandinavia is already being called in question, however, and in the opinion of the lecturer the rate at which the trees are now being felled for other purposes besides that of conversion into wood-pulp renders it probable that, in spite of the laws regarding replanting which are in operation in Sweden, the maintenance of the present supply will become increasingly difficult within 25 years. It is stated that timber suitable for pulping purposes requires about forty years for its growth in Sweden or Norway, whereas in Southern Germany the trees attain a sufficient size in 14 or 15 years.

Quantities of wood-pulp are also imported into Great Britain from the following foreign countries:—Russia, Germany, Holland, Portugal and the United States. The contributions from these sources are, however, insignificant in comparison with the imports from Scandinavia, and in 1903 the total amount received from other foreign countries was only 22,639 tons.

Within recent years Canada has developed a considerable export trade in wood-pulp, and in view of the great forest wealth of the Dominion there seems every probability that the country will prove an important source of supply in the future, especially if steps are taken to enforce adequate replanting in order to replace the trees felled. During 1903 Canada exported 71,677 tons of wood-pulp to this country, and at the present time considerable progress is being made both in the establishment of new mills and in the extension and improvement of those already in existence.

Wood-pulp can only be economically produced in those countries where large supplies of suitable timber are available and which also possess adequate water-power, as the employment of any other form of energy is too expensive. There are two different systems, which will be described subsequently, of

converting wood into pulp, one of which is a purely mechanical process, whereas the other involves chemical treatment. Soft woods, such as those of the Coniferæ, are most suitable for treatment by the chemical process, and in Europe the common spruce and the silver fir are the principal species utilised, whilst in America the white and black spruces, the Canadian hemlock, the white American pine and the silver fir are employed. For the production of mechanical pulp, spruce and fir are also used, together with ash, birch and different species of poplar. Latterly, however, pulp-mills have been started in many parts of the world, notably in the United States, to utilise local supplies of timber other than those mentioned above, and in some cases special processes have been devised to suit the particular material employed.

Trees from 6 to 20 inches in diameter at the base, and of about 20 years' growth, are considered to be most suitable for pulping purposes, as smaller logs are not so conveniently worked, and larger ones are more valuable as timber. The wood is usually received at the mill in the form of logs from 6 to 10 feet in length, but in the lumber districts many of the mills also utilise the waste wood from the saw-mills. Attempts have been made to prepare chemical pulp from sawdust, but this has been found impracticable owing to the difficulty experienced in obtaining a proper circulation of the liquor through the mass. The use of shavings is also troublesome on account of their extreme bulkiness.

The two methods used in the preparation of wood-pulp, viz. the mechanical and chemical processes, yield products which differ both in composition and properties, and they will consequently be treated separately. Before proceeding, however, it will be convenient to allude briefly to the nature of the processes employed in order that the different characters of the two forms of wood-pulp may be clearly understood.

In the manufacture of mechanical pulp the wood is comminuted sufficiently by grinding, and the product, after being washed, is made into sheets or boards. Such pulp is composed of the unaltered wood fibres. Chemical pulp, on the other hand, is made by treating the wood with various reagents, whereby the lignified tissue and mineral matter are removed, and a pulp

consisting of cellulose fibres, more or less pure, is obtained. Several varieties of chemical pulp are prepared at the present time, the principal forms being known as sulphite pulp, soda pulp and sulphate pulp according as calcium bisulphite, caustic soda or sodium sulphate is employed in their manufacture.

Mechanical Pulp.

The first machine for the preparation of wood-pulp by mechanical means was patented in Germany by Keller in 1844. Keller sold his patent to the firm of Voelter, who effected numerous improvements in the process and succeeded in producing pulp suitable for use in paper-making. The machine patented by Henry Voelter in 1858, and subsequently improved, still remains one of the standard types. A large number of other machines have also been patented for the production of mechanical pulp, those due to Oser, Voith, Freitag and Abadie being the most important. It is impossible in the present abstract to furnish any particulars regarding these different machines, but the following summary will indicate the main features of the process now generally adopted.

The various woods which are generally employed for the production of mechanical pulp have been specified already, and the first operation at the mill consists in the removal of the bark from the logs, which is usually accomplished by means of a machine furnished with knives set upon a revolving drum. The presence of knots is also objectionable, and any present are carefully removed, a revolving or a spoon-shaped auger being usually employed for the purpose. The logs are then cut into blocks of suitable length, and these are finally split in order that any decayed portions may be rejected. Unless these preliminary operations are carefully conducted the quality of the pulp will be adversely affected.

The comminution of the wood is effected by means of a sand-stone grindstone which is usually fixed upon a horizontal shaft and revolved at a very rapid rate, being kept wet by a constant stream of water. The wood is pressed against the stone in such a manner that its longitudinal axis is parallel to the grinding surface, and the particles torn off are carried by the water into a large vat, and afterwards to the sorting machines where they are

separated according to their size. The sorting machines consist essentially of a series of sieves which can be made to shake rapidly, giving from 400 to 500 motions per minute. After this mechanical separation the particles which are sufficiently fine for pulp are run into settling vats, whilst the larger pieces are re-ground and again passed through the sieves. The pulp thus obtained is either used immediately for paper-making or it is converted into boards or dry pulp as may be required.

In some processes the wood is submitted, before grinding, to a preliminary treatment such as steaming or immersion in a hot alkaline bath, whereby the material is softened and the adhesion of the fibres is diminished, so that the grinding is greatly facilitated. It is claimed that some of these processes furnish a pulp of superior quality which gives a paper of special toughness and tenacity. Attempts have also been made to prepare a mechanical pulp without the necessity of grinding, and in the Rasch-Kirschner process this is attained by cutting the steamed wood into small pieces and submitting these to the action of a stamping mill. The pulp obtained in this way is said to furnish good brown boards or stout wrapping papers.

Mechanical wood-pulp is utilised for the production of the coarser grades of pasteboard for use by bookbinders, box-makers, and others, but its chief application is in the manufacture of inferior grades of paper. If properly prepared it can be converted into paper by itself, but in order to accomplish this it is necessary that the pulp should be passed direct from the grinders to the paper machines, as it then possesses a greater felting power than after drying. It is only where this course is possible that paper can be prepared on fast-running machines from mechanical pulp alone. The product is only of poor quality, however, and possesses the undesirable property of darkening on exposure to light. In this country about 20 per cent. of chemical pulp has to be added to the mechanical pulp in order to hold it together on a fast-running machine, and the paper upon which our daily newspapers are printed usually consists of 70 or 80 per cent. of mechanical and 20 to 30 per cent. of chemical pulp. Enormous quantities of wood-pulp are required to satisfy the demands of the newspapers, and the lecturer stated that on a fair estimate the daily requirements of a large London

paper would represent about 10 acres of an average forest. In the course of the discussion it was also stated, in illustration of this same point, that the daily issue of a half-penny paper, with a circulation of 200,000, consumes the pulp furnished by 200 average trees.

Some particulars regarding the power necessary for the production of mechanical pulp and the cost of manufacture are given in the paper. On an average 90 h.p. is required to produce one ton of dry pulp per day, and the modern mills in Norway are supplied with at least 250 h.p. for each stone, whilst in Canada the stones, which are usually of large size, are furnished with 300 to 350 h.p. each. The cost of the wood required for the production of one ton of dry pulp is estimated as follows :—

In East Norway	25*s*. to 30*s*.
In North Sweden	22*s*. to 25*s*.
Canada : Lake St. John and portions of Nova Scotia	13*s*. 6*d*. to 15*s*.
Canada : St. Maurice River and other districts	15*s*. to 22*s*.

The net cost of producing wet pulp, after allowing for depreciation, is given approximately in the following statement, the values being expressed for comparison per ton of dry material :—

	£	*s*.	*d*.
Modern Mills in Norway . .	3	0	0
„ „ „ Sweden . .	2	15	0
Canada : Lake St. John . . .	1	17	6
„ St. Maurice district . .	2	10	0

Chemical Pulp.

Wood-pulp prepared by chemical treatment is much superior to that obtained by grinding, and its production upon a commercial scale effected a great change in the utilisation of wood-pulp for paper-making, as this form of the product gives much better qualities of paper. The sulphite process, which has been previously mentioned, was the first to be introduced, and the earliest patent was granted to B. G. Tilghman, of Philadelphia, in 1867. His process yielded an excellent pulp, but he was unable to overcome the technical difficulties which arose when attempts were made to conduct the operations upon a manufacturing scale, and was subsequently compelled to abandon his

experiments. It is noteworthy, however, that his original specification practically covers the various methods employed by subsequent inventors. The problem of producing chemical pulp was attacked by a large number of workers, of whom Ekman and Mitscherlich attained the greatest success, and gradually a suitable commercial process was developed. It is impossible here to trace the various stages of the experimental work, but the following account will give some idea of the way in which the sulphite process is worked at the present time :—

The process consists essentially in heating chips of wood, under a pressure of about seven atmospheres, with a solution of calcium or magnesium bisulphite for a period varying from eight hours to three days. The first step is the preparation of the sulphite liquor, which is accomplished by passing sulphur dioxide, obtained by burning sulphur or pyrites, up a tower filled with limestone kept moist by a descending stream of water. The gas dissolves in the water to form a solution of sulphurous acid, and at the same time some of the limestone is dissolved, with the ultimate formation of a solution of calcium bisulphite. The liquor obtained in this way usually has a specific gravity of about 1·055, and contains about two-thirds of the sulphurous acid in the free condition. This method is in general use in Sweden and Norway, but recently a new process has been introduced in which the sulphite liquor is prepared by passing sulphur dioxide through milk of lime, whereby a solution of much more uniform strength is obtained. In the Ekman process a solution of magnesium bisulphite is employed in place of the calcium salt.

The logs are freed from bark and knots in the manner described for the preparation of mechanical pulp, and are then passed into a machine, which rapidly reduces the wood to small chips. These are screened, and any knots which escaped detection previously are removed, after which the chips are carried by a conveyor and fed into the digester through a hopper. In many cases the digesters are of large size, capable of producing 15 tons of dry pulp at one operation. The sulphite liquor is run in until the wood is just covered, the lid is then secured, and steam is introduced until the temperature rises to about 100° C. The heating causes the expulsion of the air from the pores of the

wood, and its replacement by the solution. The temperature is then slowly raised by passing in more steam until about 117° C. is reached, and care has to be taken that this temperature is not greatly exceeded. The chemical action commences at a temperature of 115° C., and the maximum temperature permissible is 120° C., so that the operation requires careful regulation. The progress of the action is ascertained by the withdrawal and examination of samples of the liquor, and when complete the digester is blown off, and the pulp is washed with hot water. The pulp is then put into "potchers," where it undergoes a further washing, after which it is passed through screens in order to separate any unattacked particles, and is finally converted by machines into sheets containing 50 per cent. of moisture. If bleached pulp is desired, the requisite quantity of bleaching powder, from 10 to 20 per cent. of the weight of material, is added in the "potchers," and the whole is emptied into steeping tanks. When the bleaching action is complete the liquor is drained off, the pulp is restored to the "potchers," thoroughly washed, and treated as before.

In the soda process, a solution of caustic soda is employed to disintegrate the wood instead of the sulphite liquor, but the general details of the process are the same in both cases. The time of boiling is from 8 to 10 hours, and it has been stated that when this process is employed the temperature can be raised quickly, but with certain woods, at any rate, it appears to be necessary that the temperature should be both raised and lowered very slowly. The full pressure is attained as quickly as possible, however, and is maintained until the end of the operation. Formerly it was customary to work at a pressure of 60 to 75 lb. per square inch, but afterwards 100 or 110 lb. per square inch was employed, the strength of the solution being diminished as the pressure is increased. After the operation the caustic liquor is regenerated and used again. The product obtained by the soda process is of similar nature to sulphite pulp, and has a greyish-brown colour, but although darker than sulphite pulp, it is easier to bleach.

Within recent years the soda process has gone out of use to a large extent, and has been replaced by a new method in which the wood chips are treated with a solution of sodium sulphate

containing a certain amount of caustic soda. This "sulphate" process is conducted in much the same way as the older method, the alkaline liquor being regenerated for subsequent use, and the amount of pulp produced by this treatment is stated to be increasing every year.

Chemical wood-pulp is largely utilised for the manufacture of the higher qualities of paper, and so well is the product now prepared that it requires an expert to distinguish a paper composed of chemical wood-pulp from an expensive rag paper. Differences of opinion exist regarding the permanence of wood papers, and many leading experts hold that not even the very best bleached pulp can be safely used in the manufacture of a paper required to possess lasting qualities. In view of the progress which has been effected, however, it is not unreasonable to suppose that further improvements in the manufacture of wood-pulp may furnish material suitable for every kind of paper. The imports of chemical pulp into Great Britain show a steady increase during recent years, and in 1903 they amounted to 233,102 tons, valued at £1,724,094, only 1,356 tons of which came from British Possessions. The imports of mechanical pulp during the same year were 343,051 tons, valued at £782,489, and of this total Canada supplied 71,677 tons.

Wood-pulp has also received a number of technical applications other than those already mentioned. Thus for example it is used in the manufacture of the explosive "gun-cotton," for which purpose the pulp has to be of a special nature; considerable quantities are employed for the preparation of the so-called artificial silk; and it is utilised under the name of "Cellulose wadding" as a substitute for cotton wool as an absorbent. Another very interesting application of wood-pulp is its utilisation for textile purposes, and at the present time "paper yarn" is being produced commercially from specially prepared wood-pulp by two different processes. Mitscherlich in 1889 took out a patent for the production of thread from short wood-fibre, but the processes which are now in practical operation are based upon the patents of Calviez and Co. and R. Kron, the products being known as "xyloline" and "silvaline" respectively. The material used in these processes consists largely of chemical pulp which is specially treated in a beating engine in order to

reduce the length of the fibres sufficiently to form a good felting pulp. A thin layer of this pulp is obtained on a Fourdrinier machine, and is divided into fine strips, which are afterwards twisted and converted into yarn by means of very delicate machinery. The product is strong and can be readily converted into fabrics which it is stated will stand washing without damage. It is expected that paper yarn will enter into direct competition with jute and possibly with coarse cotton yarn. Factories producing either silvaline or xyloline are already working in Spain, near Bilboa, in Holland, and at Rattiman and Mesterlitz in Germany. This industry may prove to be of commercial importance, and its future developments will be watched with considerable interest.

Further particulars regarding many of the points here dealt with will be found in the original paper, which also contains a summary of the most important patents covering the developments in the manufacture of wood-pulp since 1867.

PRODUCTION AND UTILISATION OF CORK.

IT is remarkable that, although the cork-oak is known to grow well in many countries, and particularly in South Africa and Australia, the supply of cork should still be derived almost entirely, as it has been for centuries past, from a comparatively small group of countries in southern Europe and northern Africa. It might have been supposed that the development of the wine trade in Australia and the Cape Colony would have implied the development of cork-growing in those two Colonies, but such does not appear to be the case. In connection with this subject of the cultivation and utilisation of cork a Manual by M. Martignat, "Le Liège: Ses produits et ses sous-produits," recently published by Messrs. Gauthier-Villars, Paris, is of interest.

Producing Areas.

Natural forests of cork-oak exist in the following countries the following figures giving approximately the areas under this tree in the respective countries:—Portugal, 1,500,000 acres; Algeria, 1,150,000 acres; Morocco, 750,000 acres; Spain, 625,000 acres;

France and Corsica, 400,000 acres; Tunis, 335,000 acres; Italy, Sardinia, and Sicily, 200,000 acres; and smaller areas in Istria and Greece. The districts possessing cork-oak forests are the basin of the Tagus, Catalonia, Andalusia, Estramadura, Gascony, Pyrénées Orientales, Navarre, Alpes Maritimes, Corsica, Tuscany, Sicily and Sardinia. In Morocco there are large areas under the cork-oak fit for opening up, but the exportation of cork is prohibited: the bark is used by Arabs as a tanning material and to make charcoal. Algeria and Tunis also have large areas covered with the tree and not yet regularly exploited. In Algeria, the province of Constantine has 580,000 acres, the province of Algiers 130,000 acres, and the province of Oran 15,000 acres of cork-oak forest.

The Bark.

The "male cork," or natural bark, has not the qualities essential in cork that is to be used for industrial purposes. It is inelastic, and has numerous crevices due to the presence of lenticels or fissures. To improve the quality the natural bark is stripped off, and the exposed part forms a new layer—the "female cork," which is far more homogeneous, soft, and elastic than the "male cork," and which constitutes the cork of commerce.

Rinding is effected by making a clean cut round the trunk of the tree at its base, taking care that the cut does not go so deep as to injure the inner tissues, and a second circular cut at three feet or more above the level of the ground, the height of the upper cut depending upon the thickness of the trunk of the tree. The bark between the upper and lower cuts is stripped off by methods very similar to those employed in rinding an oak to obtain the bark for tanning. The operation requires care, as rinding takes place in the case of the cork-oak on the erect living tree, and wounds of the mother-zone injure the tree, and check the formation of the next year's layer of bark. The time of year for rinding is when the sap is rising, generally May or June, but in some localities the work goes on until September. To ascertain when to rind, the sides of the trees facing north are tested by probing. If the cork easily becomes detached the tree is ready for rinding. Some rinders are guided by examination

of the crevices, the inner parts of which show a pink colour when the sap is rising.

Yield.

The average yield is about two tons of cork per acre every ten years, or about four hundredweight per acre per annum, representing a value of £10 per acre per annum. The quantity and quality of the cork depend upon climate, soil, and the age of the tree. Proper management of the forest is of importance, as the yield is capable of being artificially augmented by the exercise of care in rinding.

In Sardinia a yield higher than the average is obtained by these means. The average value of the yield of a tree is about 28*s*. for each period of growth—seven years—or 4*s*. per annum.

In Algeria—where a period of ten years is usual—the average yield is only about half-a-hundredweight per acre per annum, and the average value of the yield of a tree about 3*s*. per annum.

The total yield of all the cork-producing countries of the Mediterranean region is about 80,000 tons of cork yearly.

The Forests.

The forests have as a rule a dense undergrowth of lentiscus, heath, myrtle, and other bushes, which seriously check the growth of the bark, particularly up to the height to which rinding takes place. The undergrowth must be kept down. It is, moreover, necessary to take precautions against forest-fires, which are very liable to occur in the dry countries in which cork-oak grows. Fire-belts about 100 yards broad should be established in the usual way. The cork itself is a natural preservative against fire, so much so that trees on which the female cork is several years old are the least likely to suffer in a forest-fire. All the trees on which there is only one year's growth of cork, and about half of those on which there is a four years' growth, may be expected to perish in a forest-fire, whereas, it is stated, most of those on which there is a nine years' growth will probably survive.

Preparation of the Bark.

After rinding, the rolls or strips of bark are removed to a depôt, at which they are stored. The tendency of the bark to

curl up is checked by piling it in stacks while still fresh. Before being sold the bark is submitted to a process of preparation, in order to raise its value in the market by increasing its elasticity and homogeneity. The bark is taken from the depôt to the factory, where the process of *boiling* is effected either in water or steam. This lasts about half-an-hour, the object being to cause swelling of the substance, with the result that the pores close, the elasticity is increased, and the whole substance becomes more homogeneous.

The bark then undergoes *scraping* to remove the outer crust formed on exposure to the air, a layer which is inelastic and of little use. In some countries the bark, without being boiled, is scraped by hand in the forest, but the work is tedious, and less satisfactory than if the bark is first boiled, when scraping may be readily effected by hand or machine. Scraping by hand is now, as a rule, only employed for bark of the best quality, entailing as it does somewhat heavy expenditure on labour. The cost of scraping by machine is much lower, and a machine deals with a far larger quantity of cork per diem. The scraping machine removes prominences but leaves cavities untouched, and these can only be obliterated by scraping more closely. The loss of weight during scraping is about 25 per cent.

The next stage is *sorting*, according to thickness and quality, usually into four grades—thick cork, ordinary cork, thin cork and waste.

In *packing*, the various sorts are arranged together in bales 4 ft. 6 in. long, 2 ft. 6 in. broad, and 2 ft. high. Rectangular bottomless cases having these dimensions are placed on the ground, a strip of bark of approximately the right size is put at the bottom, and on it are piled smaller pieces up to a height of 2 ft. 8 in. On the top is placed another large strip of bark similar to the one placed at the bottom. The bales, temporarily bound by cords, are put into a press. After being pressed, they are permanently bound up with wire.

Sale.

The bales thus prepared are arranged in stacks, and left to dry as completely as possible. Sale of the cork generally takes place

in September, the bales having by that time attained their lowest weight. During winter they tend to go up in weight, owing to absorption of moisture from the atmosphere. The price varies considerably, and depends upon quality, place of origin, age of tree, age of bark, and general appearance. At Palamos, in Spain, the price of prepared bark ranges from *2d.* to *7d.* per lb., in Algeria from ½*d.* to 1*s.* per lb.

Sometimes the cork is sold on the living tree in the forest, the purchaser estimating approximately the value of the crop while it is standing—a custom open to serious objection in view of the fact that the estimate is necessarily erroneous, and the purchaser collects all the cork he can get as rapidly as possible, observing none of the precautions necessary to avoid injuring the trees. This practice is prevalent chiefly among owners of small blocks of forest who have not the apparatus required for proper treatment of the bark.

The value of the annual output of cork is approximately as follows :—Portugal, £480,000 ; Spain, £380,000 ; France and Corsica, £150,000 ; Algeria and Tunis, £150,000 ; Italy, Sardinia and Sicily, £30,000.

During the last fifty years the Mediterranean production of cork has more than doubled.

Uses.

If the object is to make an ordinary bottle cork, the material is generally obtained from Algeria, Corsica, Sardinia, or France, while the best qualities are reserved for making champagne corks, and come chiefly from Spain. The bales of cork are exposed in heaps to the air, which gradually effects physical and chemical changes, removing mineral salts, and so enhancing the value. After a time the bales are opened, and the pieces of bark sorted according to quality and thickness. Manufacture of corks by hand economises material, reducing waste to a minimum, and produces the best article. Manufacture by machinery entails greater waste, but the number of corks produced is much greater, 10,000 to 40,000 a day, and the cost relatively lower. In both the procedure is essentially the same. A piece of bark is cut into strips corresponding to the length of the corks, and the strips are then cut into squares. The corners are removed by

a special machine. The hand method is now practised only where labour is cheap, and is gradually being abandoned.

Sorting into sizes is the next step. This is done by a machine which deals with 30,000 corks of each size an hour.

For the manufacture of champagne corks perfectly sound material is required, capable of resisting a pressure of five or six atmospheres at high temperatures. The principal centres of production of champagne corks, in order of precedence as regards quality, are Gerona, Estramadura, Andalusia, Portugal, Corsica, Sicily and Sardinia.

Although manufacture of corks is the purpose for which cork is most extensively employed, large quantities are also used in making life-boats, life-belts, buoys, floats, bungs, washers, penholders, cork-paper, handles of bicycles, interiors of tassels; while the gardener, the lace-maker, the cobbler, the hatter, the cigarette-maker, the dressmaker, the milliner and the entomologist, all add to the demand.

Pieces of cork too small or otherwise unsuitable for any of the above-mentioned purposes, together with odds and ends cut off in the early stages of preparation, and male cork, may be ground up, and the pulverised cork so obtained used either as a packing material for fruit or in the manufacture of the composite floor-cloths, linoleum, corticine and kamptulicon. The linoleums comprise monochrome linoleums and lincrusta, and are made of a paste spread upon jute or some other vegetable fibre, the paste usually consisting of pulverised cork, linseed oil, and resin. Recently attempts have been made to introduce a new kind of linoleum, linoburgau, which consists of a paste like that just described, but sprinkled with pulverised fragments of burgau, an ornamental coloured shell from the West Indies. This process, however, has not yet been perfected.

Composite-corks are made by subjecting to high pressure a paste of pulverised cork and resin.

Cork-bricks are made of a paste of pulverised cork with plaster, cement, lime, magnesia, or tar. The paste is subjected to pressure in rectangular moulds. The cork-bricks thus formed are used as building material in arches, roofing, and wherever extreme lightness is required.

As a non-conductor of heat, cork is useful in arts and

industries, and is employed in several ways in which that property can be turned to account. Cork waste has also been employed for the manufacture of an illuminating gas, which has the advantage over coal gas that it is free from sulphur compounds, and does not therefore produce sulphurous acid when burnt.

RUBBER CONCESSIONS IN NATAL.

THE Natal Government is offering to lease the rights of rubber collection in certain portions of the Ingwavuma District of Zululand for a period of five years, and is inviting tenders from persons interested in the production of rubber. The area to be leased lies to the east of the Pongola River, and has been divided into three sections which have approximate areas of 110, 150 and 350 square miles respectively. A copy of the conditions upon which the leases will be granted, and a plan showing the limits of the different sections, can be seen at the office of the Agent-General for Natal, 26, Victoria Street, London, S.W., or at the Imperial Institute. A copy of the last report of the Conservator of Forests, Natal, which deals with the rubber industry in the Colony, may also be consulted. Tenders will be received at the office of the Tender Board in Natal up till 12 noon on Monday, 1st January, 1906.

The chief rubber-yielding plant occurring in Zululand is a vine, known by the natives as "Ibungu," which has been identified as *Landolphia Kirkii*, Dyer. This plant is well known as one of the most important sources of rubber in East Africa. Samples of the rubber prepared from it in Zululand were forwarded some time ago to the Imperial Institute for analysis and valuation. They were found to be of good quality and were valued at about 4*s*. per lb. in London, at a time when fine Para was quoted at 4*s*. 8*d*. per lb. Particulars regarding the distribution of this vine in Zululand are given in the report by the Conservator of Forests to which reference has already been made.

PRODUCTION AND USES OF ASBESTOS.

THE term asbestos is applied in commerce to minerals which split up into thin flexible fibres that can be spun into thread and

woven into cloth. The term asbestos covers, however, several distinct minerals which fall into four groups, differing in chemical composition and physical characters.

1. *Tremolite Asbestos.*

This mineral is essentially a silicate of magnesium and calcium.

The following table gives a series of typical analyses of tremolite taken from Merrill's *Non-Metallic Minerals*, New York, 1904, p. 185.

	Theoretical Composition.	Taberg, Sweden.	Bolton, Massachusetts, U.S.A.	Cunsdorf, Saxony.	Frankenstein, Silesia.	Parkton, Maryland, U.S.A.	Shinness, Sutherland.
Silica . . . . SiO_2	57·69	59·75	58·80	57·98	57·69	56·96	56·86
Alumina . . . Al_2O_3	—	—	—	0·58	—	0·52	0·23
Ferric Oxide . . Fe_2O_3	—	—	—	—	—	—	0·48
Ferrous Oxide . FeO	—	3·95	3·05	6·32	2·46	1·12	2·12
Manganous Oxide MnO	—	0·31	—	—	0·13	—	0·23
Lime . . . . CaO	13·46	14·25	16·47	12·95	13·39	13·84	12·53
Magnesia . . . MgO	28·85	21·10	22·23	22·38	23·68	23·90	23·92
Potash . . . . K_2O	—	—	—	—	—	not determined	0·44
Soda . . . . Na_2O	—	—	—	—	3·14		0·54
Loss on ignition . . .	—	—	—	—	0·17	2·37	2·32
Fluorine	—	1·16	—	—	—	—	—

	Corsica.	Portsoy, Scotland.	The Balta, Scotland.	Roanoke, Virginia, U.S.A.	Zillerthal, Tyrol.	Cow Flats, Bathurst, N.S.W.	Chester, South Carolina, U.S.A.
Silica . . . . SiO_2	56·72	56·31	56·15	55·81	55·08	54·75	54·66
Alumina . . . Al_2O_3	0·54	0·77	1·54	1·66	1·64	1·21	3·72
Ferric Oxide . . Fe_2O_3	—	0·53	0·39	—	—	—	—
Ferrous Oxide . FeO	1·73	2·32	3·11	6·81	4·57	2·79	6·83
Manganous Oxide MnO	trace	0·15	0·77	—	0·81	trace	trace
Lime . . . . CaO	14·72	12·58	11·72	12·74	14·65	13·99	12·81
Magnesia . . . MgO	23·63	23·31	22·46	21·09	22·56	22·93	19·87
Potash . . . . K_2O	not determined	0·44	0·19	—	—	not determined	not determined
Soda . . . . Na_2O		0·63	0·69	—	—		
Loss on ignition . . .	2·33	2·94	2·5	1·81	2·39	2·58	2·28

These analyses show a fairly uniform composition not departing to any great extent from that given by the formula. A portion of the magnesia is, however, in every case replaced by iron.

The minerals analysed are as alike in their physical characters as in their chemical composition. They vary, however, in colour

from white to a dull green according to the percentage of iron present. The fibres have an angular, typically rhombic, section and considerable length, sometimes as much as two feet, but they are not sufficiently flexible to be well adapted for spinning and weaving and are often deficient in strength.

Tremolite crystallises in the monoclinic system and in a polarising microscope the angle between the direction of extinction and the length of the fibre varies, according to the position in which the fibre lies, from zero to a maximum, which is usually about 15°, but in some cases may be as much as 20°. If the fibre is coloured, it is pleochroic. The birefringence or the relative retardation of the fast and slow light waves in a unit of length is equal to about 27 thousandths (·027), so that a fibre a hundredth of a millimeter thick would give a pale straw-coloured tint, in the diagonal position in polarised light. The light with the greatest velocity vibrates approximately at right angles to the length. The mineral is not as a rule very strongly coloured by aniline dyes. It fuses only with difficulty and is practically unaffected by a candle or ordinary gas flame, but in a bunsen flame the fibres of some varieties fuse with comparative ease. It is not attacked by acids and has a specific gravity of about 3 and a hardness between 5 and 6 on the usual scale.

Tremolite asbestos is usually associated with metamorphic rocks. It appears to be an alteration product of diopside, a form of augite with the composition $CaMg(SiO_3)_2$, corresponding to a percentage of 55·55 of silica, 25·93 of lime, and 18·51 of magnesia. The diopside is first converted into uralite, which consists of fine prisms of hornblende packed together so that the whole has the outward form of the diopside. This change is accompanied by a decrease in the percentage of lime and increase in that of magnesia. Subsequently the whole mass is sheared out by earth movements and the long fibres of the asbestos are produced. The same result may be obtained artificially by beating out masses of uralitised diopside.

2. *Anthophyllite Asbestos.*

This is very similar to tremolite asbestos in its mode of occurrence and most of its physical characters. It differs somewhat in composition, all the lime in the tremolite being replaced by magnesia, and it is usually represented by the formula

($Mg_4Si_4O_{12}$), there being one molecule of magnesia for each molecule of silica. A part, however, of the magnesia is replaced by iron; and the water present, indicated by the loss on ignition which is fairly constant, appears to represent another molecule, so that the analyses point to the formula $Mg_6FeH_2Si_8O_{24}$.

The following are some typical analyses:—

		Theoretical Composition $Mg_4Si_4O_{12}$.	Theoretical Composition $Mg_6FeH_2Si_8O_{24}$.	Mitchell Co., N. Carolina, U.S.A.	Nacoochee Co., Georgia U.S.A.	San Diego, California, U.S.A.	Salls Mtn., Georgia U.S.A.	Alberton, Maryland, U.S.A.	Lenoir Caldwell Co., N. Carolina U.S.A.	Carbon Co., Wyoming, U.S.A.
Silica	SiO_2	60·00	59·26	59·00	57·73	57·31	57·12	56·75	56·21	54·56
Alumina	Al_2O_3	—	—	0·91	0·72	1·57	0·75	1·54	2·78	1·47
Ferric Oxide	Fe_2O_3	—	—	—	—	—	—	—	—	—
Ferrous Oxide	FeO	—	8·89	6·09	8·61	7·06	6·36	10·76	8·58	12·39
Manganous Oxide	MnO	—	—	—	—	—	—	trace	trace	—
Lime	CaO	—	—	0·45	0·08	—	—	0·10	0·82	1·86
Magnesia	MgO	40·00	29·63	29·90	28·77	30·24	29·44	27·46	28·95	25·28
Potash	K_2O	—	—	0·43	0·14	Not determined.				
Soda	Na_2O	—	—	0·68	0·57					
Loss on ignition		—	2·22	2·35	2·52	2·73	5·47	2·88	2·23	2·95

The principal physical distinction between anthophyllite asbestos and tremolite asbestos lies in the fact that in the case of the former, which belongs to the orthorhombic system of crystallisation, the direction of extinction between crossed nicols is always parallel to the length of the fibre.

Anthophyllite asbestos has hitherto been chiefly recognised in the United States, but there is little doubt that many of the occurrences in other parts of the world usually referred to tremolite asbestos will prove to be anthophyllite.

Anthophyllite is sometimes found as a compact mass which can be beaten out to form the fibrous variety in the same manner as in the case of the uralitised diopside; and this change also appears to occur in nature.

In deposits of tremolite or anthophyllite asbestos the percentage of fibrous mineral is often fairly high, so that it can be mined at comparatively low cost, but the price obtained is not very remunerative.

3. *Chrysotile Asbestos or Amiantos.*

This is one of the minerals included under the general expression serpentine. It is a hydrous silicate of magnesia with the

formula $Mg_3H_4Si_2O_9$. The magnesia, however, is replaced to some extent by ferrous oxide and lime, and part of the silica by alumina.

The following are some typical analyses :—

	Theoretical Composition.	Thetford, Quebec.		Shipton, Quebec.	Victoria, British Columbia	Commercial Sample from Italy.	Reichenstein, Germany	Near Mount Troodos, Cyprus.
Silica	43·48	40·57	39·05	42·04	41·95	40·30	43·50	40·54
Alumina . . .	—	0·90	3·67	—	—	2·27	0·40	1·09
Ferrous Oxide .	—	2·81	2·41	3·66	2·81	0·87	2·08	4·87
Magnesia . .	43·48	41·50	40·07	39·54	41·62	43·37	40·00	39·02
Combined water	13·04	13·55	14·48	14·31	14·85	12·72	13·80	13·47
Moisture . .	—							1·13

This mineral invariably occurs in fine tightly packed fibres, in veins in serpentine rock with which it is identical in composition. The fibres are at right angles to the walls of the vein. Both chrysotile and the serpentine in which it occurs are formed by the hydration of rocks rich in magnesia. A little tremolite asbestos is occasionally found associated with the chrysotile.

The extinction is parallel to the length of the fibre and the vibrations in that direction are those that travel with the least velocity. The birefringence is about half that of tremolite asbestos, so that a section of ·01 millimeter in thickness shows only a feeble greyish-white light between crossed nicols. If dried for some hours at 120° C. and then dipped in a solution of a basic coal tar dye such as rhodamine it is strongly coloured. It becomes brittle in an ordinary gas flame but only fuses when in very thin fibres. In a bunsen flame, on the other hand, it fuses easily. It is decomposed by acids, especially sulphuric, with the formation of fine gelatinous fibres.

Chrysotile asbestos forms but a very small percentage of the rocks in which it is found ; the cost of mining is therefore much higher than that of the other kinds. The value of this mineral is, however, much greater.

4. *Crocidolite or Krokidolite.*

This is a silicate of iron and soda. The proportions of the different constituents vary considerably. The formula has been given as $NaFe(SiO_3)_2FeSiO_3$; a portion of the soda is frequently replaced by water.

The following are some typical analyses :—

		Theoretical composition.	Orange River Colony.	The same.	Rhode Island, U.S.A.
Silica	SiO_2	49·6	52·11	52·11	51·56
Alumina	Al_2O_3	—	1·01	—	—
Ferric Oxide	Fe_2O_3	22·0	20·62	20·26	16·90
Ferrous Oxide. . . .	FeO	19·8	16·75	16·51	21·22
Lime	CaO	—	—	0·75	—
Magnesia	MgO	—	1·77	1·88	0·15
Soda	Na_2O	8·6	6·16	5·79	0·33
Loss on ignition		—	1·58	3·53	3·79

The high percentage of silica is partly due to the substitution of water for soda, and partly perhaps to the commencement of the process of silicification, which ultimately converts the mineral into the hard material known as tiger's eye, which is largely used for ornamental purposes.

Crocidolite is a fibrous material of a blue or greenish tint, and occurs in veins with the fibres at right angles to the walls in the same manner as chrysotile. It is more or less pleochroic, showing a change from dark bluish-green to pale violet. The character of the pleochroism varies, however, in different specimens. The maximum angle of extinction is also very variable, being sometimes almost nil and sometimes as much as 19° or 20°. The birefringence is slightly less than that of tremolite asbestos. The light with greatest velocity vibrates parallel to the length. In this respect it differs from all the other asbestiform minerals. The fibres have usually a rhombic section, the smaller angle measuring about 56°. The crystalline system is usually monoclinic, but some forms may be orthorhombic.

It is not attacked by acids or coloured by a solution of rhodamine. It has a hardness of 4, a specific gravity of 3·2 to 3·3, and is easily fusible in an ordinary gas flame, swelling to the black magnetic glass and colouring the flame yellow. Like the other asbestiform minerals it appears to be a secondary product.

There are a variety of substances known as "Mountain Wool," "Mountain Leather," and "Mountain Cork," which are similar in composition to amphibole or chrysotile asbestos, but have fibres irregularly felted together so as to form a soft elastic mass.

Distribution and Uses.

The value of asbestos-like minerals depends on their resistance to the action of heat and acids, their non-conductibility with respect to heat, their softness and the facility with which they are capable of being spun and woven.

Tremolite and anthophyllite asbestos undergo least alteration by the action of great heat, but in strength and flexibility and adaptability for textile purposes they are usually far inferior to chrysotile asbestos (amiantos), which is sufficiently resistant to fire for all practical purposes, in spite of the large amount of water it contains. Crocidolite asbestos, on the other hand, though sufficiently soft and fibrous to be easily spun and woven, yet is very inferior to chrysotile asbestos in fire-resisting power.

The most striking application of these fibrous minerals is in the manufacture of fireproof objects for the protection of life and property from fire. Fireproof curtains for theatres, clothing for firemen, and ropes for escape from burning buildings are all prepared from chrysotile asbestos, the tremolite and anthophyllite asbestos being, as has been stated, not sufficiently flexible, and the crocidolite asbestos too fusible.

The asbestiform minerals are also employed in gas fires, where they are acted on by a powerful flame produced by a mixture of coal gas and air, as in the bunsen burner, and become white hot. For this purpose tremolite and anthophyllite asbestos should be employed as they are least affected by heat.

Different forms of asbestos are also used in machinery, either in the shape of yarn or rope for packing valves, cocks, pistons, piston-rods, and throttle valves, or in the form of millboards for packing the joints of steam-pipes. In the former case, where the asbestos is employed in moving parts, the superior softness of chrysotile asbestos renders it the most suitable material, unless it is liable to come in contact with acids.

As a poor conductor of heat asbestos is employed for covers to steam cylinders, steam chests, and steam pipes, and in other cases where it is required to prevent the loss or passage of heat.

Crude asbestos itself does not rank among the highest of non-conducting materials.

The following table shows the relative value as non-conductors of heat of asbestos in various forms as well as of other substances that have been used for the same purpose:—

Hair and asbestos in alternate layers	100
Granulated cork (fire-proofed)	77
Mineral slag wool	75
Diatomaceous earth	71
Magnesium carbonate (Magnesite)	70
Diatomaceous earth and hair in paste	63
Asbestos millboard	47
Diatomaceous earth and asbestos in paste	46
Crude asbestos	36
Large air space	18

It is stated that one preparation of asbestos will, when used as the covering of a steam-pipe, save 87 per cent. of the condensation on account of the close parallel packing of its fibres which leaves no space for air (see the *Electrician*, Vol. liii., p. 836, 1904, and liv., p. 639, 1905).

If it be carefully worked up and felted, or woven, so as to increase the air space included, it becomes of much greater value. The office of the asbestos, therefore, appears to be mainly to prevent the setting up of convection currents in the surrounding air space. Even low grade material may be so felted as to become a valuable non-conductor. The fire-resisting character of the asbestos gives it an advantage over most other non-conducting substances, except mica and diatomaceous earth. Some of the forms of asbestos have also, as has been stated, the additional merit of not being attacked by acids.

Inferior grades of chrysotile asbestos are used in the manufacture of paper, paint, wall plaster, and many cements, while the finer qualities are employed in giving weight to silk.

A patent has recently been taken out for the manufacture of slabs and boarding from asbestos for use in the construction of houses, its non-conducting and non-inflammable properties rendering it very suitable for the purpose. As inferior qualities of the mineral can be employed, the product is by no means expensive. It is true that chrysotile and krokidolite asbestos are less fireproof than tremolite and anthophyllite asbestos, but they are non-inflammable, and if they could be substituted for

wood in the floor and partitions of houses the risk of fire would be greatly diminished.

Asbestos is also employed as a filtering material, especially for corrosive liquids. For this purpose tremolite and anthophyllite asbestos are most suitable, chrysotile asbestos being affected by acids. Crocidolite may be used, but only if the material collected on the filter does not afterwards require to be ignited.

THE UTILISATION OF SANDS CONTAINING THORIUM MINERALS.

SINCE the discovery of thorianite, thorite and similar minerals in Ceylon and of monazite sands in Southern Nigeria by the officers of the Mineral Surveys now being carried on under the direction of the Imperial Institute in these countries, a number of enquiries have been received for information as to the methods best adapted for winning these valuable minerals from the comparatively valueless gravels and sands with which they occur associated. It has been considered advisable, therefore, to publish a general statement on this subject, giving the results of experience in Brazil and Carolina, which have up to the present been the principal centres of production of these minerals.

1. *Brazil.*

The Brazilian monazite deposits (hitherto the chief source of thorium dioxide) have been already concentrated by natural processes.

The monazite originally occurred in granites and gneisses. These were decomposed by lateritisation, broken up by subaërial agencies and transported by streams to lower ground where a series of beds of clay, sand and conglomerates containing monazite were laid down. Where these deposits have been attacked and broken up by the sea, the material has been washed and re-washed by the waves in successive tides so that the lighter material has been removed, and beds of monazite, ilmenite and garnets formed within the tidal limits. These minerals sometimes occur mixed one with the other, sometimes in alternate layers, and in most cases the monazite beds are

covered with a layer of other material. In some instances where the relative level of land and sea has changed the deposits are found above high-water mark.

The monazite beds rarely exceed half-a-metre in thickness but occasionally reach a metre. They are lenticular in shape, thinning out towards the sea. The richer deposits only occasionally reach and rarely exceed a length of 500 metres along the seashore. Their width is usually rather under 20 metres. No deposits of this type containing less than 15 per cent. of monazite have been worked until recently, and some yield as much as 70 per cent.

Most of these deposits are not renewed by the action of the sea, and will be exhausted soon, but the great deposits at Prado, which yield according to various estimates from 1,200 to 1,600 tons of monazite sand per annum, are being continually enriched by the destruction of the monazite-bearing clay cliffs at the foot of which they lie.

The methods of work on the Brazilian deposits are usually very simple. If there is a superincumbent bed of quartz sand or other valueless material, it is carefully shovelled away till "yellow sand," as the monazitic material is usually called, is left exposed. This is then loaded into sacks containing 45 kilograms and carried on men's heads to a series of "tanks" or wash-boxes on the banks of the nearest stream. These are placed one above the other, and a current of water passed through them which washes away the salt and the lighter material, leaving the monazite in a concentrated state. In the operations at Prado sluice-tables are employed. Monazitiferous river gravel is now being worked on the river Parahybe. The treatment is of a scientific character. The fine material containing the monazite is first separated by means of a revolving sieve or trommel. The quartz or other valueless light material is then removed by means of Wilfley tables of the usual type, and the heavy residual portion is run through Humboldt Magnetic Separators which remove the ilmenite. It is stated that, by the application of these well-known processes, gravels, containing not more than 2 per cent. of monazite, a product worth £28 per ton can be prepared.

The ultimate product exported contains 95 to 96 per cent. of

monazite, and yields on an average 3·7 per cent. of thorium dioxide. It is loaded for export in sacks containing 60 kilograms.

The cost of excavation, treatment and transport to the nearest port is rarely less than 50 or more than 120 milreis, that is from £2 10*s.* to £6, while the freight to Europe is about 12*s.* The total cost of placing a ton in Hamburg may be taken at £3 10*s.* to £7. This includes all expenses except those of litigation, which are often considerable, and official dues and exactions. The average price of material of this quality in recent years has advanced from £20 to £28 per ton, and has a tendency to rise. The price is often quoted at so much per unit per cent. of thoria (thorium dioxide) per ton of sand, and the greater the percentage of thoria, the higher the value per unit per cent., as the cost of the extraction of the oxide from rich monazitic sand is less than from poor material.

2. *North and South Carolina.*

In North and South Carolina the sands are usually roughly concentrated by the farmers. The beds of the streams have now been exhausted, and it is mainly the adjoining alluvial deposits in the valley bottoms that are worked. The gneiss, the original source of the monazite, is decomposed to a considerable depth *in situ,* but it is not worked at present for the mineral. In a few cases, however, the soil and subsoil overlying the gneiss are brought down from the hillside to the streams to be washed.

The monazite-bearing sands are concentrated in sluice-boxes 8 feet long, 20 inches wide, and 20 deep. A perforated iron plate is fixed at the upper end of the box on to which the gravel is charged by one man, while another works the contents up and down with a "gravel fork" or perforated shovel in a current of water so as to float off the lighter sand. At the end of the day the monazite is collected and dried in the sun or on sheet-iron over a fire. Magnetite is then removed by means of a large hand magnet. A concentrated sand containing from 65 to 70 per cent of monazite is considered of good quality, and the separation of 40 to 70 lbs. of material of this character is a good day's work.

The impurities include zircon, ilmenite, rutile, brookite, corun-

dum and garnet. Richer material may be obtained by more thorough washing, but in such a case a lower box or even more than one must be employed to save the monazite carried over. By these means material containing 85 per cent. of monazite is obtained which may be again treated by winnowing in a dry state, but this lengthy treatment involves considerable expense as well as loss of monazite.

Recently, concentrating mills have been established. In some, if not all of these, separation is carried on by electro-magnetic methods. In some cases the Wetherill electro-magnetic separator is employed. The finer material containing the monazite is separated from the dried concentrate by some form of sieve and allowed to pass over a revolving drum, and is thus scattered evenly over an 18 inch belt. This passes under four electro-magnets which have small belts under the poles which carry the material attracted out of the magnetic field. The first magnet, which has the weakest field, removes only the ilmenite and part of the garnet, the magnetite having been previously extracted by hand magnets. The second removes the rest of the garnet, and the third and fourth the monazite.

The commercial value of the Carolina monazite is diminished by the size and hardness of the crystals which render them difficult to dissolve in acids. It is necessary to reduce them to powder before treatment.

PRODUCTION OF MONAZITE.

The United States produces about 200 tons of monazite per annum and the Prado deposits of Brazil about 1,600 tons per annum. The total output of the remainder of Brazil is not known. It may perhaps amount to another 2,000 tons, but these deposits, unlike those of Prado, are, as has been stated, not renewed indefinitely. The total amount of monazite in Brazilian deposits of this class, containing over 15 per cent. of the mineral, is estimated at 16,000 tons.

EXTRACTION OF HEAVY MINERALS FROM CEYLON SANDS.

With regard to the working of the Ceylon sands containing thorianite, thorite and other heavy minerals everything

depends on the local conditions. Except near the sea coast there are probably few rivers which are deep enough and contain sufficiently extensive alluvium to make it desirable to employ floating dredges. Probably the contents of the river beds could be best reached by diverting the water in the dry season and removing the payable gravel, which could either be concentrated by washing at once, or, if sufficient water were not then available, accumulated in heaps until the rainy season. The alluvial material in the valley bottoms could probably also be more economically mined in the dry weather, as there would be less water to deal with. The work of excavation should be carried out on a large scale in an open quarry. In most cases there would be no doubt an overburden to be removed before the valuable deposits below could be dealt with.

If, as is probably the case, the grains in the material to be treated vary considerably in size, it should first be sized by dry sorting. It should then be carefully washed in a couple of sluices arranged in series one below the other. This should suffice to give a product that is practically free from quartz and felspar and other light material. More complicated machinery would require constant adjustment according to the minerals present and their size, and would require skilled labour and highly paid superintendence. The materials worth collecting in different sands are often very close in their specific gravity to minerals such as zircon and ilmenite, for which there is little demand. It will be better, therefore, after having obtained a comparatively clean, heavy sand to resort to magnetic methods of separation. Magnetite is easily removed by permanent magnets, ilmenite can be raised by electro-magnets in fields of moderate strength, and fergusonite and garnet in rather stronger fields. The material left will be composed mainly of zircon, thorianite, thorite, rutile, tinstone, gold and various rare minerals. From this the thorite and rutile can be separated if the strength of the field is still further increased, though it will not be easy to effect complete separation. After the magnetic treatment it will be much easier to carry out still further separation by washing in sluices, moving tables or tubular hydraulic classifiers.

A tubular classifier has been devised in which the water passes upwards between two concentric cylinders. Sized material is fed into a hopper and ultimately passes outwards through a horizontal groove in the inner cylinder into the upward current. Here the heavy grains sink against the current and pass down into a locked receptacle, while the lighter material rises with the water. In a large installation several of these separators are employed, the material being graded according to size in trommels, so that each size is dealt with in a special separator in which the current is so adjusted that separation will take place at the density required. A simple form of this apparatus might usefully be employed for the final treatment of magnetically separated material.

The possibility of finding the thorianite or other valuable minerals *in situ* in decomposed rock which can be easily worked should not be neglected, though the prospects of success are seriously diminished by the fact that these minerals are usually found in ancient alluvium laid down by former streams, and that since it was deposited immense quantities of rock have been removed from the surface of the country by subaërial agencies. Finally it must not be forgotten that heavy minerals containing thoria or other valuable material may be found in a finely divided state in the alluvium of the lower courses of the rivers and the adjoining flats as well as in the sands of the seashore. Too much stress cannot be laid on the importance of systematic work, adequate machinery and skilled superintendence in the exploitation of these heavy minerals, which vary so much in their characters, contents and value.

NOTICES OF RECENT LITERATURE.

NEW BOOKS.

CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1904. Bulletin No. 260. United States Geological Survey. (Washington: Government Printing Office, 1905.)

This Bulletin is the third of a series of annual publications, the object of which is to summarise the results of economic investigations carried out by the Geological Survey.

It contains sixty-three articles, contributed by thirty-seven members of the Survey who have been specially engaged in economic work. The contributions are classified according to the subject dealt with, and a comprehensive account is given of the progress of investigation in the various mining localities.

At the end of each section a useful bibliography is given. The Bulletin has been prepared with a view to prompt publication; hence many of the observations and discussions are essentially of a preliminary character. In economic investigations, however, the advantages of prompt publication are obvious, and much that is merely preliminary in the way of new observations is sure to be very useful. These promptly published contributions to economic geology will be keenly welcomed by all who are interested in the mineral resources of the United States, while to those who are concerned with the actual development of those resources, they will prove especially useful

THE TOPOGRAPHY AND GEOLOGY OF THE FAYÛM PROVINCE OF EGYPT. By H. J. L. Beadnell, F.G.S., F.R.G.S., Survey Department, Egypt. Pp. 101. (National Printing Department, 1905.)

The Fayûm is a large circular depression in the Libyan Desert, situated immediately to the west of the Nile Valley and occupying the site of the ancient Lake Moeris, which has now shrunk to the much smaller sheet of water known as the Birket-el-Qurun.

After describing the physical characters of the province, which is watered by a branch of the Nile, the author discusses the proposal to utilise the Wadi Rayan, a deep depression to the westward, as a Nile reservoir in the same manner as Lake Moeris was employed in former times.

The geology is then dealt with in considerable detail. Overlying nummulitic limestone of middle eocene age is a fluvio-marine series which is referred to the upper eocene and oligocene. The miocene is absent, but is represented by similar deposits in the depression of Mogara some 100 kilometres to the north-west. The oligocene is covered by marine pliocene and by beds of gypsum probably deposited from sea water, but in pleistocene times the depression appears to have been

occupied by the fresh-water lake which persisted into the historical period. At the base of the fluviomarine beds Dr. C. W. Andrews, of the British Museum (Natural History), found extensive remains of mammals and reptiles which he has since described.

The book is illustrated by a number of plans and sections as well as by sixteen full-page reproductions of photographs.

THE GEOLOGY OF CYPRUS. By C. V. Bellamy, M.I.C.E., F.G.S., and A. J. Jukes-Browne, B.A., F.G.S. Pp. 72. (Plymouth: Wm. Brendon & Son, Ltd., 1905.)

Mr. Bellamy was formerly Director of Public Works in Cyprus, and in that capacity had numerous opportunities of studying the geology of the Island. He embodied his observations in a geological map on the scale of $5\frac{1}{2}$ miles to the inch. The present work, which has been prepared in conjunction with Mr. Jukes-Browne, is intended as an explanatory memoir to accompany this map. It is a useful summary of what is known at present of the geology of the Island, and should be in the hands of those who are interested in its agricultural or mineral development.

The following table is stated to show the general succession of formations in the Island:—

Name and Age.		Characters.	Thickness in feet.
Pleistocene		Alluvial deposits, sandy limestones, sands and conglomerates	Up to 50.
Pliocene		Shelly limestones, with calcareous sands and sandstones	100 to 150.
Break		Intrusion of igneous rocks.	
Idalian.	Newer (Miocene)	White shelly limestones, white chalky limestones, and marly chalks with layers of flint	About 1000.
	Older (Oligocene?)	Grey and yellowish marks, with beds of gypsum	400.
Kythræan (Upper Eocene or Oligocene)		Grey felspathic sandstones and sandy shales	? 1500.
Trypanian.	Eocene?	Greenish shales with hornstone bands	? 100.
	Cretaceous?	Grey limestones and dolomites, white and pink marbles, both massive and laminated	Possibly 5000.

The oldest beds are a thick series of limestones which have been strongly affected by earth movements, and have assumed a nearly vertical position. They have been repeatedly penetrated

and altered by igneous rocks, and are sometimes schistose in structure. The principal exposures are in the Kyrenian Mountains, which skirt the northern shore of the island. Many are completely crystallised and yield decorative marbles, which often show a brecciated structure. These beds contain no recognisable fossils, but were considered by Gaudry to resemble the cretaceous limestones of Greece.

They are overlaid, the authors believe conformably, by a series of shaly marls and fissile limestones with chert. These are referred to as the Lapithos beds, and are presumably the greenish shales with hornstone bands mentioned in the table. They contain remains of foraminifera, which indicate an eocene or possibly oligocene age.

The Kythræan series is exposed on the flanks of the Kyrenia Mountains, as well as at several points on the south coast. They have yielded no fossils except a few small tests of globigerina and minute fragments of molluscan shells. These are considered by the authors as proving that the deposits are of marine origin, but it must be remembered that such calcareous grains are often carried by the wind a considerable distance inland.

The greater portion of the Idalian series consists of fine chalky marls and limestones with layers or bands of flint. These beds contain few fossils except foraminifera, chiefly globigerina; they are occasionally covered by shelly limestones which appear, on the evidence of their fossils, to be of Miocene age. The Idalian beds are in some places considerably disturbed, especially in the neighbourhood of the igneous rocks, where they have been much affected by contact metamorphism. Certain coral-bearing rocks found near Cape Greco were believed by some authorities to belong to the Jurassic period, but are referred by the authors to the same horizon as the shelly limestones. This view has the approval of Dr. Hinde. There are extensive exposures of igneous rocks, most of which appear to have consolidated after the deposition of the Idalian series. They are chiefly met with in the mountain ranges in the south of the Island, and include both acid and basic rocks. They have been described in some detail by Professor Bergeat, and an abstract of his paper is included in the present work. The most interesting are the peridotites, which have been largely converted into serpentine.

*

Deposits of pliocene age are extensively developed in the central plain as well as along the coast, demonstrating that at that period all the lowlands were under water, and the Island was converted into an archipelago. The pleistocene deposits are more limited, those of marine origin being restricted to the immediate vicinity of the present shore line.

The geology of the Island presents many difficulties, and there are important problems that still await solution. The key to some, at least, of these will probably be found in the adjoining continental region, which is closely related in its fundamental structure.

The authors devote considerable space to the mineral products of economic interest, which include marble and ordinary limestone for building and burning, gypsum, alum, road metal and asbestos. The last is really chysotile, the asbestos of commerce, not the true asbestos of mineralogists. The miocene flints are, we are told, used for studding the undersides of small sledges employed in threshing corn ; a procedure that also prevails in Spain. The statement that the so-called Paphos diamond consists of quartz is not quite correct, for the term is applied in some cases at least to clear crystals of analcime.

There is good reason for believing that further investigations will add considerably to the list of valuable mineral products.

A large number of the specimens described by the authors have been recently added to the collection of mineral products from the island in the Scientific and Technical Department of the Imperial Institute.

ARBEITEN AUS DEM PHARMAZEUTISCHEN INSTITUT DER UNIVERSITÄT BERLIN (Researches made in the Pharmaceutical Institute of the Berlin University). Edited by Dr. H. Thoms. Vol. i. Researches of the year 1903. Pp. viii.—229. Vol. ii. Researches of the year 1904. Pp. xii.—391. (Berlin : Julius Springer.)

The Pharmaceutical Institute, which forms part of the Berlin University, was opened in October 1902, under the directorship of Dr. H. Thoms. The work of the Institute includes both the instruction of students and the performance of a large amount of research work, chiefly relating to drugs and medicinal agents.

Among the papers in the first volume is one on the fruit and oils of the oil palm *Elæis guineensis*, which are among the most important commercial products of West Africa. The fruit is of the size of a small plum, and is composed of a hard seed surrounded by pulp. The pulp yields a semi-solid oil, palm oil, which is extracted locally and exported. The seeds contain a kernel which also yields a semi-solid oil, but of a different nature to palm oil, and known as palm kernel oil. This latter is not extracted locally, but the kernels are exported to Europe, where the oil is obtained from them either by pressure or by the use of solvents.

With a view to future planting operations it is of considerable importance to ascertain the relative merits of the different varieties of the oil palm. In the Cameroons a variety known as "Lisombe" or "Isombe" has been found, the fruit of which is characterised by having the outer shell of the seed so thin and weak that it can be broken with the teeth, whilst the seed of the common variety requires the blow of a hammer to open it; the fruit of this variety is also rich in oil-bearing pulp. Four varieties of oil palm fruit were forwarded from Togoland to the Institute, and their composition and the properties of the oils they contained are recorded in great detail. It was found that all of them were inferior both to the "Lisombe" and to the ordinary variety growing in the Cameroons.

Among other subjects treated in this volume are the candle nut (*Aleurites moluccana*) from the Cameroons; the "Coyal" fruit (*Acrocomia vinifera*) from Nicaragua; melon seeds from Togoland; the seeds of *Telfairia pedata*, from German East Africa, all of which contain notable quantities of oil; the seeds of *Monodora myristica*, valued by the natives of West Africa for their aroma; lemon grass oil, from a species of *Andropogon* growing in the Cameroons (70 per cent. of citral and no citronellal were found in this oil); and a native dyestuff from Togoland resembling Indian madder.

In the second volume a considerable space is devoted to *Strophanthus* in its botanical, chemical, and clinical aspects, and also to the methods of examining caoutchouc. An account is given of results obtained with Haake's machinery for separating oil palm fruit into outer pulp, shells and kernels, and for obtain-

ing the oil from the outer pulp. Among other subjects treated of are the fruit of the Baobab Tree (*Adansonia digitata*), false Yohimbé bark; Parkia bark, and the fruit and oils of *Melia Azedarach*, *Carthamus tinctorius* and *Calophyllum Inophyllum*.

NOTICES SUR DES PLANTES UTILES OU INTÉRESSANTES DE LA FLORE DU CONGO. By Émile de Wildeman. III. Pp. 397–659. (Publication de l'État Indépendant du Congo, 1905.)

Parts I. and II. of this publication were noticed in the *Bulletin of the Imperial Institute*, Vol. iii., p. 105, where the general nature of the work is described.

The present volume contains seven independent articles, which whilst especially written to be of service to cultivators in the Congo are, from the cosmopolitan characters of the plants treated of, likely to prove of interest and practical utility to agriculturists in all parts of the tropics.

A comprehensive summary is given of available information on the ground nut (*Arachis hypogea*), comprising agricultural, commercial and chemical data gathered from the results of cultural and experimental work in all parts of the world. The allied leguminous plant (*Voandzeia subterranea*) is similarly treated.

Attention is directed to the Indian "bead tree" (*Melia Azedarach*), and chemical facts summarised regarding the composition of its seeds and the oil they yield. Forage plants are treated at great length, and much useful information is given regarding the culture, composition and relative value of the chief grasses, leguminosæ and other plants of known value as tropical fodder plants.

The composition and uses of the oil extracted from the seeds of the Baobab tree (*Adansonia digitata*) are recorded.

Kapok, the product of the white silk-cotton tree (*Eriodendron anfractuosum*) is discussed, special attention being devoted to the occurrence of the tree, the extent to which its silk-cotton is utilised and the exports from the countries where it has been put to practical account. Analyses of the seeds and their oil are given.

The Castor-oil plant and allied species of *Ricinus* are next dealt with, and their botanical, chemical and economic characters discussed.

The concluding paper deals exhaustively with the Sansevierias of Africa, well known as the source of "bow-string hemp." The various species are described, illustrated by figures indicating the characteristic shapes, in section, of their leaves, and in addition much useful information is brought together regarding their culture and the quality of their respective fibres.

The part contains four plates and an index to this and the two parts previously reviewed.

ALL ABOUT THE COCO-NUT PALM. Compiled by J. Ferguson, C.M.G. Pp. xi.–87 and i.–cxcii. Third Edition. (Colombo: A. M. & J. Ferguson, 1904.)

The compiler, who was for many years the editor of the *Tropical Agriculturist*, was from his position well qualified to produce this volume, which is intended to bring together in a convenient and easily accessible form the scattered published information relating to this important plant in the East. Originally published in 1885, the book has been sufficiently appreciated to call for the issue of a third edition. An historical account is given of the cultivation of the palm in Ceylon, and present methods of cultivation are described in detail, chiefly by coco-nut planters, with, in some cases, full estimates of expenditure and receipts. A new feature in this edition is a short chapter on the preparation of desiccated coco-nut, which has recently been produced on a large scale in Ceylon.

Although primarily written with reference to Ceylon, information is given on coco-nut cultivation in South India, the Straits Settlements, Queensland and the West Indies, and all phases of the cultivation of the plant, the preparation, marketing, and uses of its products are dealt with.

The book is well indexed, a vital necessity in a publication of this kind, in which information on any one product or subject may occur in several independent and scattered articles.

RECENT JOURNALS.

DER TROPENPFLANZER—ZEITSCHRIFT FÜR TROPISCHE LANDWIRTSCHAFT.

This journal is published by the German Colonial Economic

Committee, an organisation which devotes attention to the exploitation of the economic resources of the German Colonies. The *Tropenpflanzer* is published monthly and contains principally articles contributed by experts dealing with the cultivation or production of economic products in particular colonies, and descriptive accounts of the journeys of the missions which the Committee from time to time despatches to study local conditions, cultural methods, etc., in various parts of the tropics. The current number contains several articles of special interest. There is a useful account of the methods adopted in the cultivation of Paraguay tea, the leaves of *Ilex paraguayensis*, in Nueva-Germania, contributed by Herr von Fischer-Treuenfeld, German Consul-General in Paraguay, in which information is given as to the statistics of production of the material, the market available in South America and elsewhere, and the amount of capital necessary before embarking in the industry. Dr. Winkler gives a short account of a number of economic plants which are being experimentally grown in the Botanical Gardens at Victoria in the Cameroons, and which should afford useful information to local planters. Other articles deal with the important discovery of the West African rubber tree, *Funtumia elastica*, in Uganda, and with the cultivation of coffee as carried on in the Oaxaca Province of Mexico.

Particulars are also given, in a series of notes, of the operations and progress of various German companies occupied in planting, railway and similar enterprises in German colonies and elsewhere.

With the current number is issued a supplement of nearly 200 pages dealing exhaustively with the project of building a railway from Kilwa to Wiedhafen through the southern portion of German East Africa.

COLONIE DE MADAGASCAR ET DÉPENDANCES—BULLETIN ÉCONOMIQUE. (Imprimerie Officielle de Tananarive.)

This journal, which is published quarterly under official sanction at Tananarive, is devoted to the dissemination of information regarding the natural resources of Madagascar and their development, and also serves as a medium for the publication of articles of general interest to planters in the island.

The number last received (No. 1 of 1905) contains a review, by the Chief of the Service of Mines, of the mining industries in Madagascar during 1904, and this furnishes a summary of information regarding the extent and nature of the auriferous rocks of the Island. The export of gold from Madagascar during 1904 is given as 2460 kilos, an increase of 550 kilos on the figures for the previous year. This review is supplemented by a statement drawn up by one of the Controllers of Mines for the information of prospectors regarding the methods and precautions to be adopted in the examination of veins of auriferous quartz in order to determine their value. The agricultural interests are represented by a paper upon the breeding of cattle, whilst the articles on drinking waters and on the thermal and mineral waters of Antsirabe, in the province of Vakinankaratra, are of general interest to people in the Island. Local and European market reports are given, as well as a general statement regarding the trade of Madagascar during 1904, and the section of short notes and abstracts from current literature supplies information upon a number of topics of special interest to planters in Madagascar.

COLONIAL PUBLICATIONS.

Copies of the following publications, descriptive of the resources of the British Colonies, have recently been received. They are available for distribution at the Central Stand in the Exhibition Galleries free of charge, so long as numbers permit, excepting those to which prices are affixed.

FISHING AND SHOOTING ALONG THE LINES OF THE CANADIAN PACIFIC RAILWAY. (Issued by the Canadian Pacific Railway, 1904.)

The scope of this pamphlet is indicated by its title. It describes the chief sporting localities in the districts served by the railway, the facilities for reaching them, and the species of game to be met with. The booklet is well illustrated and there are three maps.

HINTS ABOUT CAMPING IN CANADA. (Issued by the Canadian Pacific Railway.)

A small pamphlet containing practical information concerning guides, clothing, provisions, etc., for those intending to camp out in the Canadian forests.

CLIMATES AND HEALTH RESORTS OF CANADA. By P. H. Bryce, M.A., M.D. (Issued by the Canadian Pacific Railway Company, 1905.)

An illustrated pamphlet containing a short description of the climate of Canada, together with references to the principal health resorts of the Dominion. The author deals with the climates of the natural regions of the country such as the Prairie, Mountain, and Forest areas, rather than with those of the political sub-divisions, which possess climates of the most varied description consequent upon the different types of country occurring within their boundaries.

MONTREAL, THE CANADIAN METROPOLIS. (Issued by the Canadian Pacific Railway Company, 1905.)

A short illustrated account of the city of Montreal and its environs.

QUEBEC, SUMMER AND WINTER. (Issued by the Canadian Pacific Railway Company, 1905.)

An illustrated guide to the principal attractions of Quebec and the surrounding country. Particular attention is drawn to the advantages of the city as a winter resort.

JAMAICA IN 1905. By Frank Cundall. (Published for the Jamaica Committee of the Colonial and Indian Exhibition London, and the Board of Governors of the Institute of Jamaica. Pp. i.–vi. and 1–116. Price *6d.*)

The present issue is a new and entirely remodelled edition of a work which first appeared under the title of *Jamaica in 1895, a brief Handbook of Information for intending Settlers and others*, compiled with a view of giving in a handy form such particulars concerning the island as might prove useful chiefly to intending settlers. Successive chapters deal with the geography, history, people, agriculture, manufactures, trade and commerce.

A special feature of the book is the series of "Agricultural Notes" which form Appendix vii. Here are brought together concise notes, written mainly by planters, or obtained from West Indian agricultural publications on all the principal agricultural pursuits of the Colony, including pen-keeping—as the breeding and feeding of live-stock is usually termed in Jamaica—and planting. The details of the articled pupils' scheme should be of considerable service to those thinking of taking up planting in the Colony. Sport is not overlooked, and the volume, which is well illustrated, forms a very convenient and reliable guide to the present conditions of Jamaica.

DOMINICA. Notes and Hints to Intending Settlers. By H. Hesketh Bell, C.M.G. (1904. Price 3*d.*)

The scope of this little book is sufficiently indicated in the title. The author is the Administrator of Dominica, and the information contained in the pamphlet should prove of considerable value to the intending settler.

NOTES FOR THE USE OF SETTLERS IN THE ORANGE RIVER COLONY. (Issued by the Land Settlement Board, 1902.)

These notes have been prepared from information supplied by a farmer of twenty years' experience in the country. The aim has not been to deal exhaustively with the various subjects touched upon, but to give a summary of the method of farming practised in the Colony, together with such other information which appears likely to be of service to settlers. A coloured map of the Colony, showing the magisterial and police districts, is given.

THE WHITE RIVER SETTLEMENT, TRANSVAAL. (Issued by the Transvaal Land Department, 1905.)

The pamphlet contains practical information respecting the White River Settlement, comprising some 80,000 acres of land in the district of Barberton, Transvaal. Information is given as to means of access, climate, soil, etc. Tropical fruit is expected to be the staple product of the district, but the proximity to Johannesburg will allow market gardening to be an important subsidiary industry. Extensive irrigation works are under construction. £500 is looked upon as the minimum capital for a bachelor, and nine settlers are stated to have already taken up land.

Appendices contain the present ruling prices for stock, building material, implements and plant, and an abstract of the Settler's Ordinance. Fourteen plates (two coloured), a map and a plan accompany the report.

NEW SOUTH WALES—THE LAND OF REWARD FOR INDUSTRY AND CAPITAL. (Issued by the Authority of the Government of the State.)

This book contains a review of the present promising condition of agriculture in New South Wales. The first part contains full information regarding the acquisition of land by settlers, and is followed by an account of the present position of the chief crops raised in the State. The pastoral industries are also dealt with.

SYNOPSIS OF THE LAWS RELATING TO THE CROWN LANDS OF THE STATE OF NEW SOUTH WALES. (Sydney, 1904.)

In addition to the information indicated by the title, the book contains full particulars of the characteristics and resources of the Land Board Districts in the Eastern and Central Divisions of the State.

NEW ZEALAND. (Issued by Authority.)

This pamphlet, which is well illustrated by photographs, contains a short general account of the Colony and the inducements it offers to intending settlers, especially in connection with the pastoral and agricultural industries. Particular attention is drawn to New Zealand as a tourist and sporting country, and to the facilities afforded by the Government Department of Tourist and Health Resorts.

WALCH'S TASMANIAN ALMANAC FOR 1905. (Issued by Authority. J. Walch and Sons, Hobart.)

This almanac, now in its forty-third year of publication, forms a general handbook to the State of Tasmania, and contains much information of value to the resident and intending emigrant. There is a good map of the island, and the usefulness of the book is enhanced by a copious index.

BULLETIN

OF THE

IMPERIAL INSTITUTE

INDIAN AND COLONIAL COLLECTIONS.

RECENT ADDITIONS.

JAMAICA COURT.

SALT FROM SALT CAY.

A SPECIMEN of salt from Salt Cay, one of the Turks and Caicos Islands, a dependency of Jamaica, was presented to the Imperial Institute, through the Colonial Office, by his Honour W. Douglas Young, the Commissioner. The principal salt-producing localities are Grand Turk and Salt Cay in the Turks Islands group and Cockburn Harbour on South Caicos. According to the *Handbook of Jamaica*, it is estimated that there are 231 acres of salt pond at Grand Turk, 114 at Salt Cay, and 248 at Cockburn Harbour. Each acre yields about 4,000 bushels of salt per annum in favourable seasons. The extraction of salt from the sea-water affords employment to about three-quarters of the population of the dependency.

The water is run into shallow reservoirs and pans on low-lying stretches of the shore known as "salinas," and evaporation is effected solely by the sun and wind. The output is consequently dependent on the prevalence of fine weather, a heavy thunder-storm, for example, doing great harm. The salt is collected by persons known as "rakers." Two qualities of the salt are recognised: "coarse" salt, as raked from the pans, and "fishery"

salt, prepared by crushing the coarse salt. Steam or aëromotor machinery is employed in the crushing process.

The average annual export is about 1,800,000 bushels (60,000 tons), chiefly to the United States; a small proportion of the export goes to Canada and the British and French West Indies. The average price is six cents (3*d.*) a bushel for coarse salt, a slightly higher price, eight cents, being obtained for fishery salt. In lieu of rent a royalty of 10 per cent. on the value of the export, assessed for this purpose at seven cents a bushel, is levied, and forms one of the main sources of revenue.

The salt is stated to be especially valuable for preserving purposes, practically the whole of the export to the United States being used in this way. At one time it was compulsory in New York State to pack meat in Turks Island salt. The fishery salt is exported to Canada, where it is used for preserving fish.

TRINIDAD COURT.

TIMBERS.

THE specimens of Trinidad products received at the Imperial Institute include a set of some twenty of the timbers occurring in the island. The samples are mostly hand specimens, but that of Trinidad cedar, presented by Messrs. Schöner & Co., is a log containing about 28 cubic feet of timber. The hand specimens are polished on one side, and were prepared by the Trinidad Government Railway Department.

The addition of these timbers to the Court has rendered the already extensive collection of Trinidad timbers practically complete. The following brief notes indicate the characters and uses of the woods recently added.

"ANGELIN" (*Andira inermis*), Leguminosæ.—A large tree, sometimes known as the Cabbage Tree, 40 to 50 feet high and 3 to 5 feet in diameter, producing fine timber when full grown. There are two kinds, red and white. The wood is strong and durable, lasts well in water, and is therefore suitable for piles and bridges, as well as for house frames, mill-rollers, and naves of wheels. It has been used for treads of steps in St. Lucia. The

grain is brown and streaky, resembling that of the wood of the coco-nut palm. Weight, 58 lb. per cubic foot. The bark, known in England as "worm bark" or "bastard cabbage bark," is a narcotic drug. (Compare *Technical Reports and Scientific Papers of the Imperial Institute*, Part I., pp. 263, 265, 267, 280.)

"LOCUST," "SIMIRI," or "COURBARIL" (*Hymenæa Courbaril*), Leguminosæ.—A tree common in the West Indies, attaining, in the best soils, a diameter up to 5 feet. The wood is of reddish-brown colour, streaked, close-grained, and extremely hard and tough. It resembles mahogany, but is much harder and liable to rot in the ground. The wood is suitable for cabinet work and furniture, as it takes a fine polish, and, on account of its freedom from splitting and warping, is well adapted for mill-timbers, cogs of wheels and engine work. Weight, 59 lb. per cubic foot. Crushing weight, 5·17 tons per square inch. (Compare *Technical Reports and Scientific Papers of the Imperial Institute*, Part I., pp. 285 and 292.) "Gum anime" (West Indian copal) is derived from this tree.

"PURPLE-HEART" (*Copaifera Martii*), Leguminosæ.—Purple-heart is one of the tallest of forest trees, the average height of mature specimens being 120 feet. Logs may be cut up to 30 inches square. The wood is of a deep blue-purple colour, hard, close-grained, durable and tough. It is suitable for furniture, cabinet making, and ornamental work, and on account of its resistance to great strains, is adapted for house-framing, mill-beds, and other structural purposes. Weight, 63 lb. per cubic foot. (Compare *Technical Reports and Scientific Papers of the Imperial Institute*, Part I., p. 285.)

"BALSAM COPAIBA" (*Copaifera sp.*), Leguminosæ.—A hard handsome ornamental wood of medium weight.

"CHINETTE."—A hard heavy timber somewhat resembling boxwood in appearance.

"CARAPA" or "CRABWOOD" (*Carapa guianensis*), Meliaceæ.—An abundant and useful wood, bearing a considerable resemblance to cedar. It is strong and coarse, and much used for house building and furniture. The tree is from 2 to 3 feet in diameter, and may reach a height of 120 feet. There are two kinds of the timber, white and red. The seeds yield the well-known "crab or 'carapa' oil," samples of which have been

examined at the Imperial Institute. (See *Technical Reports and Scientific Papers*, Part I., pp. 135 and 285.)

"WEST INDIAN CEDAR" (*Cedrela odorata*), Meliaceæ.—This "cedar," which should not be confused with the true cedars (Coniferæ), is a rapidly-growing tree, reaching a height of 80 feet and a diameter of 4 feet. The timber is dark-red in colour, fissile, open-grained, but soft and porous. It is used for planks, shingles, joinery and furniture, its peculiar odour, which repels insects, rendering it very suitable for wardrobes. It is considered the best wood for manufacturing cigar-boxes. Weight, 36 lb. per cubic foot. Crushing weight, 2·94 tons per square inch.

MAHOGANY (*Swietenia Mahagoni*), Meliaceæ.—This well-known timber comes chiefly from Central America, as "Honduras' or "Bay" mahogany, and from the West Indies as "Spanish" mahogany. The tree reaches a height of 40 to 50 feet, with a diameter of 6 to 12 feet, the logs as placed on the market measuring from 10 to 30 feet in length and from 15 to 48 inches square. Mahogany is a fine, close-grained, moderately heavy wood ranging in colour from gold-brown to red-brown; and varying in hardness. It is strong, durable and flexible when fresh, though somewhat brittle when dry. Great care is required in seasoning. The timber, as is well-known, is used for a great number of purposes, chiefly for furniture, joinery and ornamental work and in shipbuilding.

"TAPANA" (*Hieronyma alchorneoides*), Euphorbiaceæ.—A handsome dark reddish-brown timber with a straight grain; it is hard and of medium weight. The tree reaches a height of about 20 feet.

"BALATA" (*Mimusops Balata*), Sapotaceæ.—A lofty tree found in most of the West India Islands, occurring generally on hills in the forests. The trunk sometimes attains a diameter of 7 feet, and squared logs can be obtained 40 feet long. There are three varieties, red, white and black; all three afford very good timber, but the red is the best. The wood is dense, hard and heavy, having a sour smell when freshly cut. It is most durable when free of sap, and is suitable for harbour and field work, telegraph-posts, bridging, spars, mill-rollers, and carpentry and joinery. The wood, however, warps much in seasoning, and cracks when exposed to the sun. Ants will not attack balata,

except the bark, and when stored the latter should be stripped from the timber. Weight, 70 lb. per cubic foot. Crushing weight, 4·77 tons per square inch. Modulus of rupture (tested by breaking spars 6 inches in diameter), 16,000 lb. per square inch.

Mimusops Balata yields the well-known "balata" used as a substitute for gutta-percha.

"OLD FUSTIC" (*Chlorophora* [*Maclura*] *tinctoria*), Urticaceæ.—A rapidly-growing tree which lives in almost any soil. The wood, which is close-grained, hard, tough, and of a bright canary-yellow colour, is chiefly used as a yellow dye-wood, but is a handsome cabinet timber, and very suitable for the hubs of wheels. Weight, 42 lb. per cubic foot.

"GREENHEART," or "BIBIRU" (*Nectandra Rodiœi*), Lauraceæ.—This timber, one of the eight first-class woods at Lloyd's, is obtained principally from British Guiana, but is also found in Trinidad, Jamaica and Dominica. The tree is 60 to 100 feet high, and yields "baulks" 50 to 60 feet long and 18 to 24 inches square. Owing to reckless felling supplies are becoming scarce. There are three varieties of greenheart, all most serviceable and durable woods when cut mature, but liable to shrink if felled when young and sappy.

The timber has a dark-green colour, the central portion being brownish-purple or almost black. It is hard, durable, tough, elastic, and of great strength ; great care, however, must be taken in working the wood, as it is liable to split. It is much valued for marine work, such as piles, piers, jetties, dock gates, and for shipbuilding, the timber being specially suitable for such purposes on account of its property of withstanding the attacks of marine worms. (Compare *Technical Reports and Scientific Papers of the Imperial Institute,* Part I., pp. 282–285.) The bark of the Greenheart tree was at one time much used in medicine as a tonic.

"MANCHINEEL" (*Hippomane Manchinella*), Euphorbiaceæ.—The trees are generally found on sandy sea-shores. The timber is of a tawny yellowish colour, variegated with brown and white, and resembles maple in appearance ; it has an odour of lavender. The wood is highly prized in some of the West India Islands for furniture and ornaments, and is suitable for outdoor work. Weight, 50 lb. per cubic foot. In felling the trees and working the timber great care is taken to avoid contact with the very

poisonous juice or latex, which is a powerful irritant, raising blisters on the skin or injuring the sight should it enter the eye.

"MORA" (*Mora excelsa*), Moraceæ.—One of the eight first-class woods at Lloyd's, and found in British Guiana and Trinidad. The tree reaches a height of from 130 to 150 feet, but the market logs are cut 18 to 35 feet long, squaring 12 to 20 inches. There are three varieties of Mora, known as red, white, and Morabucquia; the last-named is not a durable wood. Mora is of a chestnut-brown colour, hard, heavy, tough, strong, and generally straight in the grain, but occasionally with a beautiful figure. When free of sap it is very durable, both in and out of water, and is not attacked by dry-rot. It takes a good polish, and would form a useful substitute for either *rosewood* or *Spanish mahogany* in cabinet making.

The timber is suitable for beams, large scantlings, and engine bearings. Only the best trees can be sawn into planks on account of the frequency of "star-shake" in the logs. Weight, 65 lb. per cubic foot. Crushing weight, 5·33 tons per square inch. (Compare *Technical Reports and Scientific Papers of the Imperial Institute*, Part I., pp. 282–285.)

"OLIVIER" (*Bucida Buceras*), Combretaceæ.—A large rapidly-growing tree 30 to 50 feet high with a diameter of 2 to 4 feet. The valuable timber is used for boards, planks, and all kinds of inside and outside work. It is very durable in water, and is excellent for shingles. The wood is difficult to ignite and does not flame.

"POUI," "EBONY" (*Tecoma serratifolia*), Bignoniaceæ.—Abundant in Trinidad, and one of the hardest and most durable woods in the Colony. There are two other varieties, grey and green. The tree grows to a height of from 30 to 50 feet, with a diameter of 2 to 3 feet. The wood, which has a peculiar odour and takes a fine polish, is used for posts.

"YOKE WOOD" (*Catalpa longissima*), Bignoniaceæ.—A tall handsome tree, 80 feet high and 3 feet in diameter. The wood is light brownish-grey, with cross stripes of a darker colour, and somewhat resembles walnut. It is very durable, not too hard for general purposes, and is one of the best timbers for boards and scantlings. Weight, 70 lb. per cubic foot. Crushing weight, 2·09 tons per square inch.

"AVOCADO" (*Persea gratissima*), Lauraceæ.—A common tree in the West Indies and well known for its fruit, the Avocado pear. The timber is hard, of medium weight, and has a wavy grain.

"CYP," "PRINCE WOOD" (*Cordia gerascanthus*), Boraginaceæ.—A light, useful, durable timber of a uniform brown colour with dusky eccentric zones. It is used for shingles, and, when creosoted, would probably make a good paving material. Weight, about 43 lb. per cubic foot.

BRITISH NORTH BORNEO COURT.

MANGANESE ORE.

THE British Borneo Exploration Company has presented specimens of manganese ore from a deposit situated close to Taritipan, which lies near the southern end of Marudu Bay, on the north-west coast of British North Borneo. Outcrops of the ore have been met with over an area of about twelve square miles.

Reports received by the Company state that analyses of samples from various parts of the deposit indicate that average shipments would contain manganese dioxide equivalent to from 49 to 51 per cent. of metallic manganese, 15 per cent. of silica, 0·35 per cent. of sulphur, and 0·03 per cent. of phosphorus. The silica is rather high, but the sulphur and phosphorus decidedly low. A picked cargo would contain 8 to 10 per cent. of silica and the equivalent of 51 to 53 per cent. of manganese.

It is estimated that an annual export of from 40,000 to 50,000 tons could be easily maintained.

HONG KONG COURT.

SUGAR AND RUM.

HONG KONG is the centre of an important sugar industry, although the Colony does not itself actually produce any sugar.

One portion of the trade is in the hands of natives, who import brown sugar, chiefly from Swatow—the principal sugar-growing district of South China—the Philippines, Hoihau, Touron, Canton, and to some extent from Java, and re-ship it for consumption to the northern markets of China and Japan.

Of much greater importance is the sugar-refining industry conducted by two companies, the China Sugar Refining Company, Ltd., and the Taikoo Sugar Refining Company, Ltd. The former company also possesses a distillery. The refining industry was commenced on a small scale in 1874, and has now reached large proportions, the annual output of the two companies working at full power being estimated at 250,000 tons. The principal market for the refined product is found in the northern part of China.

The China Sugar Refining Company, at the request of Sir Matthew Nathan, the Governor of Hong Kong, has recently presented for exhibition in the Hong Kong Court of the Imperial Institute a set of specimens of raw sugars, refined, cube and granulated sugars, rum and spirits of wine.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since the 16th September, 1905.

Proceedings of the Royal Society of Queensland. Vol. xix. 1905 . .	(*Secretary.*)
Ferguson's Ceylon Handbook and Directory, 1905–6	(*Crown Agents for the Colonies.*)
Kurukh Folk Lore	By Rev. F. Hahn. (*Bengal Secretariat.*)
Transactions of the New Zealand Institute, 1904	(*Secretary.*)
L'Agriculture dans les Colonies Portugaises	By A. d'Almada Negreiros. (*Author.*)

Sugar and the Sugar Cane . . .	By Nöel Deerr. (*Mr. Norman Rodger.*)
On Silk and the Silk Worm . .	By M. Arbousset. (*Mr. W. H. Eaton.*)
McGill University Examination Papers, 1904–5	(*Registrar.*)
London University Calendar, 1905–6	(*Principal.*)
University College Calendar, 1905–6	(*Principal.*)
Calendar of Letter Books of the City of London. Letter Book G. Circa A.D. 1352–74	Edited by Reginald R. Sharpe, D.C.L. (*Town Clerk.*)
The Private Diary of Ananda Ranga Pillai, from 1736–61. Vol. i. 1736–46	Edited by Sir J. Frederick Price, K.C.S.I. (*India Office.*)
Terrestrial Magnetism and its causes	By F. A. Black. (*Author.*)
Notes on India for Missionary Students	By Eugene Stock. (*Church Missionary Society.*)
Negro Humour	By J. G. Cruickshank. (*Author.*)
Report of Bengal Chamber of Commerce, 1904. Vol. ii. . . .	(*Secretary.*)
A Journal of a Tour in the Congo Free State	By Marcus R. P. Dorman, M.A. (*Messrs. Kegan Paul, Trench, Trübner & Co., Ltd.*)
In Remotest Barotseland . .	By Col. Colin Harding, C.M.G., F.R.G.S. (*Messrs. Hurst and Blackett.*)

A Practical Guide to Cookery in West Africa and the Tropics	By Sister Cockburn. (*The Scientific Press, Ltd.*)
Canadian Life in Town and Country	By Henry J. Morgan and Lawrence J Burpee. (*Messrs. George Newnes Ltd.*)
Records of Cape Colony. Oct.–Dec. 1827, Dec. 1827–April 1831. Index to Vols. 1–35	By G. McCall Theal, D.Lit., LL.D. (*Colonial Secretary.*)
Transactions of the Institution of Naval Architects, 1905 . . .	(*Secretary.*)
Kalendar of the Royal Institution of British Architects, 1905–6 . .	(*Secretary.*)
The Native Races of South Africa .	By George W. Stow, F.G.S., F.R.G.S. (*Messrs. Swan, Sonnenschein & Co., Ltd.*)
Reports on Injurious Insects and other Animals observed in the Midland Counties during 1903 and 1904	By W. E. Collinge, M.Sc.
Some Recent Investigations on the Black-currant Gall-mite . . .	By W. E. Collinge, M.Sc. (*Messrs. Cornish Bros.*)
Guide to South Africa, 1905–6 . .	Edited by A. S. and G. G. Brown. (*Messrs. Sampson Low, Marston & Co., Ltd.*)
King's College Calendar, 1905–6 .	(*Secretary.*)
Seasons in the British Isles from 1878	By W. N. Shaw, Sc.D., F.R.S. (*Meteorological Office.*)

Transactions of the Institution of Mining and Metallurgy. Vol. xiv.	(*Secretary.*)
River, Sand and Sun. Sketches of the C.M.S. Egypt Mission . . .	By Minna C. Gollock. (*Church Missionary Society.*)
The Book of Trinidad . . .	Edited by T. B. Jackson. (*W. G. Freeman, Esq.*)
Glue, Gelatine and their allied Products	By T. Lambert. (*Messrs. Charles Griffin & Co.*)
Tin Deposits of the World. . .	By Sydney Fawns. ("*The Mining Journal.*")
Report of the Second International Cotton Congress, 1905 . . .	(*Cotton Spinners' and Manufacturers' Association.*)
Culture du Caféier	By E. Pierrot. (*M. Challamel.*)
Transactions of the Nova Scotia Institute of Science, 1902–3. Vol. xi., Part 1	(*Smithsonian Institute.*)
The Newfoundland Guide Book, 1905	Edited by D.W. Prowse. (*Messrs. Bradbury, Agnew & Co.*)
The Literary Yearbook and Bookman's Directory, 1906	(*Messrs. Routledge and Sons, Ltd.*)
Annual Report of the Battersea Borough Council for the year ended 31st March, 1905	(*Town Clerk.*)

SCIENTIFIC AND TECHNICAL DEPARTMENT.

REPORTS ON RECENT INVESTIGATIONS.

COTTON FROM THE FEDERATED MALAY STATES.

IN connection with the general enquiry which is being carried on at the Imperial Institute with reference to cotton growing in the various British Colonies and Dependencies, a letter was addressed to the High Commissioner of the Federated Malay States, asking for information with regard to the prospects of cotton cultivation in these States, and also for representative samples of the products.

In reply, the High Commissioner stated that some Egyptian cotton grown in the Federated Malay States was being forwarded to the Imperial Institute for examination and valuation, but that the Resident-General was of opinion that there was little prospect of cotton cultivation becoming an established industry.

This letter was accompanied by a copy of a report by the Superintendent of Experimental Plantations, Selangor, dated the 30th August, 1904, and also by some printed correspondence, containing the opinions and experience of planters and others, on the subject of cotton growing in the Federated Malay States. The Report of the Superintendent of the Experimental Plantations contained the following particulars. During 1903, Egyptian cotton seed was sown in the Experimental Plantations at Batu Tiga, Selangor, and germinated well. The young plants flourished for a time, but during a protracted period of wet weather they were to a large extent destroyed by the attacks of a mite. The surviving plants were allowed to mature, and during the dry weather experienced in the early part of 1904 improved considerably, and yielded a small crop of cotton, which was much stained. Selected samples of this cotton (ginned and unginned) were forwarded to the Imperial Institute, and constitute the samples referred to later. There are several obstacles to the successful cultivation of cotton in

the Federated Malay States, particularly the irregularity of the climate, the severity of the attacks of insect and fungoid pests, and the difficulty of obtaining a sufficient supply of labour for harvesting operations. Experiments are being continued on a small scale with the object of establishing a type of cotton plant suited to the local conditions. If these experiments are successful, it is possible that the cultivation may be carried on by the natives and immigrant coolies with Government assistance, but it is regarded as practically certain that the industry would never repay European supervision. The tree cotton (*Gossypium arboreum*) is grown to a limited extent in Negri Sembilan and elsewhere, but the staple is too short for spinning purposes.

The two samples supplied have been examined, and their commercial values have been ascertained by reference to experts.

Sample No. 1 was labelled "Egyptian cotton (hand ginned)," and consisted of about 4 oz. of a brownish cotton of somewhat uneven colour and good average strength. On comparing this material with standard brown Egyptian cotton, it was found to be slightly inferior in colour, fineness, softness and lustre, but was of good length, varying from 1·2 to 1·5 inches.

Sample No. 2 was labelled "Egyptian cotton," and consisted of about 8 oz. of unginned cotton of apparently the same growth as sample No. 1. The seeds were smooth and dark brown in colour. The fibre was easily detached from the seed, and possessed the characters already described.

The commercial experts reported that the ginned cotton was clean, of good hard staple, mixed in colour, and worth about 5*d.* per lb., "Fully good fair brown Egyptian" cotton being quoted on the same date at 6¾*d.* per lb., and "Middling American" at 3¾*d.* per lb.

From the foregoing report, it is evident that the cotton is somewhat inferior to average qualities of Egyptian cotton. This is probably due to deterioration caused by the adverse climatic conditions to which the plants were subjected in the early period of their growth. The cotton is, nevertheless, of fair quality, and if this standard could be maintained, and a moderate yield secured, the cultivation might prove

remunerative. In any case, it certainly appears desirable that the experiments referred to in the Report of the Superintendent of the Experimental Plantations, which are being carried on with the object of establishing a type of cotton capable of withstanding the local conditions, should be continued.

THE FIBRE OF *ASCLEPIAS SEMILUNATA* FROM UGANDA.

THIS sample of fibre, derived from a species of *Asclepias* occurring in Uganda, was forwarded to the Imperial Institute for examination by H. M. Commissioner. The plant yielding the fibre was stated to occur in Bugangadzi. This plant has been identified at Kew as *Asclepias semilunata*, N. E. Br.

The sample of fibre sent for examination weighed only 4 oz., and consisted of five small bundles. The fibre was lustrous and almost white, but was marked by a few patches of a black substance, which had not been removed in the cleaning process. It possessed considerable strength, and the length of staple ranged from 2 to 3 feet.

The chemical examination furnished the following results, the percentages, other than that of moisture, being expressed on the dry material.

	Per cent.
Moisture	7·7
Ash	3·2
Loss on α-hydrolysis	12·9
,, β-hydrolysis	19·2
,, mercerisation	6·0
,, acid purification	6·2
Gain on nitration	46·9
Cellulose	80·4
Length of ultimate fibre	20–27 mm. (0·8–1·08 inches)

The percentage of cellulose is high, and the fibre is evidently of good quality, though the losses on hydrolysis and acid purification are considerable. The marked action of weak alkalis upon the fibre, as shown by the loss occurring on

hydrolysis, suggests that it may not prove very durable in use, whilst the high loss on acid purification indicates that more careful and thorough cleaning is desirable.

The nitrated fibre was nearly white, and no purple colour was produced when the fibre was treated with sodium sulphite after chlorination, both of which facts indicate that the fibre is not lignified, but consists probably of pecto-celluloses. In this respect, and also in the high percentage of cellulose, this *Asclepias* fibre from Uganda resembles the fibres of *Marsdenia* and *Cryptostegia*, and it is noteworthy that these three genera belong to the same natural order, i.e. *Asclepiadaceæ.* (Compare *Imperial Institute Bulletin*, 1903, Vol. i., pp. 121 and 172.)

The following statement summarises the results obtained in the examination at the Imperial Institute of the fibres from *Marsdenia tenacissima* and *Cryptostegia grandiflora* for comparison with those furnished by the present sample of *Asclepias* fibre.

	Fibre of *Asclepias semilunata* from Uganda. Per cent.	Fibre of *Marsdenia tenacissima* from India. Per cent.	Fibre of *Cryptostegia grandiflora* from India. Per cent.
Moisture	7·7	7·7	7·9
Ash	3·2	1·5	0·95
Loss on α-hydrolysis	12·9	7·8	5·2
,, β-hydrolysis	19·2	8·9	9·8
,, mercerisation	6·0	4·9	4·3
,, acid purification	6·2	3·5	1·2
Gain on nitration	46·9	53·9	49·0
Cellulose	80·4	91·5	92·0
Length of ultimate fibre	20–27 mm. (0·8–1·1 inches)	10–30 mm. (0·4–1·2 inches)	10–50 mm. (0·4–2·4 inches)
,, staple	2–3 feet	12–13 inches	16–20 inches

A comparison of these figures shows that this sample of *Asclepias* fibre from Uganda is distinctly inferior to the others, the percentage of cellulose being lower, whilst the ash and the losses on hydrolysis and acid purification are considerably greater. It is possible, however, that the fibre could be improved in these respects by careful preparation. In the case of *Asclepias semilunata*, the length of the ultimate fibres is not so great as in the other two fibres, but it appears to be more uniform, and the staple is much longer.

Experiments are at present being made with fibres of this type to determine their suitability for use in the manufacture of explosives, and, if it is found possible to utilise them in this way, a large demand, at prices from £20 to £25 per ton, may be anticipated. For this purpose the length of staple would be immaterial. If, however, the fibre of *Asclepias semilunata* can be obtained more uniform in length and equal to the longest fibres in the present sample, *i.e.* 3 feet, it is thought by technical experts that it would be suitable for rough textile purposes, and in this case its value would be from £10 to £15 per ton greater than the above quotation.

The fibre of *Asclepias semilunata* therefore appears worthy of further attention in Uganda, especially if the plant is abundant or can be easily cultivated. In this case efforts should be directed to the production of a uniformly long fibre, as the value of the product in this form will be much greater than if a considerable proportion of short fibres is present. The short fibres would probably only be commercially useful in the event of the technical experiments, to which reference has been made, proving successful.

"LOKOSI" FIBRE FROM NORTH-WESTERN RHODESIA.

THIS sample of fibre from North-Western Rhodesia was forwarded for examination to the Imperial Institute by the British South Africa Company. It was sent to the United Kingdom by the District Commissioner at Livingstone, Victoria Falls, who furnished the following information regarding it. The plant from which the fibre is obtained is known locally as "Lokosi," but as no herbarium specimens have been forwarded it is impossible to express a definite opinion regarding its botanical identity. A rough sketch of the plant is furnished, from which it seems probable that the latter may be a species of *Agave* or *Sansevieria*, and this view is confirmed by the character of the fibre. The plant is stated to be invariably found on the Mopani veldt, and to grow in considerable abundance along the Zambesi Valley. The natives consider the fibre to be the strongest obtainable in the country.

The sample weighed 9 oz., and consisted of well-cleaned cream-coloured fibre. It possessed fair strength, and the length of staple was 2 feet 6 inches.

The chemical examination of the fibre gave the following results, the percentages, except that of moisture, being expressed on the dry fibre. For comparison the figures furnished by the analysis of a sample of sisal hemp from the Bahamas are also given.

	Fibre from North-Western Rhodesia. Per cent.	Sisal hemp from the Bahamas. Per cent.
Moisture	9·2	12·8
Ash	1·3	4·4
Loss on α-hydrolysis	15·4	12·0
,, β-hydrolysis	21·4	16·1
,, mercerisation	12·4	13·4
,, acid purification	6·0	8·1
Gain on nitration	18·0	29·7
Cellulose	70·3	75·9
Length of ultimate fibre	0·8–3·0 mm. (0·03–0·12 inch)	——

A comparison of these figures shows that the "Lokosi" fibre is inferior to the sample of sisal hemp from the Bahamas, chiefly on account of the lower percentage of cellulose and the greater loss which occurs on hydrolysis. Its susceptibility to the action of weak alkalis (as shown by the loss suffered on hydrolysis) suggests that it may not prove so durable in use as sisal hemp, but the material might be improved in this respect by more careful preparation.

The fibre would be suitable for rope-making, but its rather short staple would reduce its market value for this purpose. Samples were submitted for valuation to commercial experts, who reported that a consignment of similar character would probably realise from £28 to £30 per ton in London at the present time, whereas if the fibre could be obtained 3 feet or more in length the price might be increased by £5 per ton.

It seems probable that this fibre could be utilised commercially, and in view of the abundant distribution of the plant in certain districts it would be worth while to prepare a trial consignment for sale in the London market.

THE TANNING VALUE OF "ELAND'S BOONTJES" FROM THE TRANSVAAL.

A SAMPLE of this South African tanning material was forwarded to the Imperial Institute by the Director of the Transvaal Department of Agriculture, who furnished the following statement regarding its use as a tanning agent in the Colony.

"'Eland's Boontjes,' the roots of *Elephantorrhiza Burchellii*, is reputed to contain a high percentage of tannin, and is used by the Boers for tanning leather. It is said, however, that the red colour which it imparts to the leather reduces its value, and that it also tends to render the leather unduly soft. On these points we have no definite information, and it is suggested that this may be due to defective treatment, and that it could be overcome by the application of expert technical knowledge."

"The plant occurs in great quantity in the Transvaal, Orange River Colony and the uplands of Natal, and we are anxious to have a thorough expert opinion on the material and its relative value in London, with a view to possible exploitation, and perhaps cultivation in regions too dry for profitable wattle culture."

Chemical Examination.

The consignment of the material received weighed about 15 lb., and consisted of a number of complete tuberous roots, which, when fresh, were plump, but on keeping lost much moisture and became shrivelled. The roots were about 12 inches in length and 2½ inches in width at the thickest part, and were covered by a thin dark-brown rind. Internally they were fibrous in structure, and showed a dull red colour distributed evenly throughout the transverse section, and especially well marked near the rind. Freshly-cut slices of the roots had a sweetish, astringent taste.

The root, as received, contained about 65 per cent. of moisture, and a portion of the material was cut into thin slices and dried by exposure to air. This dried product, which represents the condition in which the roots should be prepared for sale, was then chemically examined, and gave the following results:—

	Air-dried roots. Per cent.	Calculated for roots dried at 105° C. Per cent.
Moisture	12·0	——
Ash	2·7	3·03
Total extractive matter soluble in water	39·6	45·9
Tannin (determined by hide powder process)	19·6	22·3
Saccharine matter (calculated as dextrose)	14·6	16·8

Of the total matter absorbed by hide from tanning liquors prepared from this material, 49 per cent. was found to be real tannin, as determined by Parker and Payne's process; this is somewhat below the average of 55 to 65 per cent. usually found in the tanning materials in common use.

This result agrees fairly well with those previously recorded; thus, Proctor states that the fresh root usually contains 12 per cent. of tannin.

Small tanning trials on "limed" calf-skin were also made with liquors prepared from the roots; the leather produced was soft but fairly tough, and showed a pale pinkish-brown colour, somewhat lighter than that produced by Australian wattle bark.

It is probably this pinkish-brown tint which is referred to by the Director of Agriculture as being objected to by leather buyers. It is impossible to avoid entirely the appearance of a slight pink colour in leather tanned with these roots, but the tint is very slight when the tanning is conducted quickly, and may be rendered slighter still by adding a small quantity of sodium meta-bisulphite to the tanning liquors.

Commercial Valuation.

A large sample of the air-dried, whole roots was submitted to a tanning expert, who was informed of the results of the chemical examination, for technical trial and commercial valuation. The expert reported that the material would be worth about £2 10*s*. per ton. It is probable that a well-prepared specimen cut into slices and thoroughly dried in the air before shipment would bring somewhat better prices than this.

General Conclusions and Recommendations.

The foregoing results indicate that the roots of *Elephantorrhiza Burchellii* form a fairly satisfactory tanning material for local

use, but that it is doubtful whether it would pay to export them. As a general rule it is not remunerative to export materials containing less than 30 per cent. of tannin, unless, like sumac, they possess some particularly valuable characteristic not readily procurable in other tanning materials.

It is possible that it might pay to prepare a tanning extract from the roots of *Elephantorrhiza Burchellii* for export, but there are several difficulties in the way of doing this. The roots contain a considerable quantity of a sugar, which would find its way into the extract, and the latter would, therefore, be liable to ferment, and for that reason would be difficult to store or transport, especially in hot countries. Further, the red colouring matter present in the roots would also appear in the extract, and this would to some extent detract from its value as a tanning agent, especially in European countries. It might be possible to free the extract from this red colouring matter by bleaching it with sulphur dioxide, or by the addition of sodium meta-bisulphite; but there is a certain amount of prejudice among tanners in European countries against the use of extract bleached in this way, and it is not advisable to adopt this plan if it can be avoided.

Taking these considerations into account, it will be seen that it would be advisable to confine the exploitation of the roots of *Elephantorrhiza Burchellii* as a tanning material to local use, and if it is desired to cultivate tanning materials in the Transvaal Colony for export, to devote attention to some richer tanning material already well known in European commerce.

The Imperial Institute has been informed recently that a large tannery has been opened in the Orange River Colony by a British firm which proposes to utilise these roots as suggested in the foregoing report.

BLACK DAMMAR RESIN FROM ASSAM.

A SMALL consignment of this resin was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, with the information that it had been collected in Cachar, Assam, and asking for a report

on its chemical characteristics and its commercial value, and for some information as to the possibility of creating an export trade in this product.

Chemical Examination.

The resin was chemically examined in the Scientific and Technical Department of the Imperial Institute, and has given the results recorded below.

The sample consisted of large flattened pieces of resin, usually with small portions of bark adhering to its surface. The resin was of a dull dark-brown colour, and showed a glassy, conchoidal fracture.

It dissolved readily in oil of turpentine and in benzene, chloroform or acetic anhydride, but was only partially soluble in alcohol or ether.

The resin melted at 125° C., and yielded on ignition 0·78 per cent. of mineral ash. Its saponification value was 9·43, acid value 8·15, and ester value 1·28. When a drop of concentrated sulphuric acid was added to a solution of the resin in acetic anhydride a deep purple coloration was produced; the addition of sulphuric acid to a solution of the resin in chloroform gave a yellow coloration, which slowly changed to ruby red.

These results indicate that the resin is of the dammar type, although it differs to some extent from the black dammar of commerce stated to be derived from *Canarium strictum*, especially in possessing lower acid and saponification values.

Commercial Valuation.

Specimens of the resin were submitted to varnish manufacturers for technical trial, and to commercial experts for valuation, together with a statement of the analytical results given above. The varnish makers reported that the resin was suitable for the preparation of a hard drying varnish, such as is required in the manufacture of enamel paints. The dark colour of the resin would, however, to some extent prejudice its sale, and it is unlikely that a higher price than 18*s*. per cwt. could be obtained for it.

The possibility of creating an export trade in this product will depend upon whether the price quoted will prove remunerative to exporters in India, and also upon whether a regular supply of the resin can be maintained.

"MUTEKE" RUBBER FROM NORTH-EASTERN RHODESIA.

IN a previous issue of this *Bulletin* (this vol., p. 14) an account was given of a preliminary examination of "Muteke" rubber from North-Eastern Rhodesia, and the information there supplied may now be supplemented by the results of a further investigation of larger samples, which have been received from the British South Africa Company.

Identification of the Plant.

From the imperfect botanical specimens which were first forwarded it was thought that the plant might prove to be a new species of *Landolphia*, but the later specimens have not confirmed this view. Three additional specimens of the "Muteke" vine were forwarded for examination, and these bore the following labels:—

(1) "Leaves of rubber-yielding (female) Muteke vine, Mwaba, Chambesi River. April 23, 1905."

(2) "Leaves of non-rubber-yielding (male?) Muteke vine, Mwaba, Chambesi River. April 23, 1905."

(3) "Muteke, bushy form, from stony hills, Mirongo. Top sprigs with young leaves and buds. November, 1904."

These specimens were referred for identification to the Director of the Royal Gardens, Kew, who reports that (1) and (2) are *Landolphia Kirkii*, Dyer. This vine is one of the most important sources of rubber in East Africa, where it is widely distributed. In the letters accompanying the specimens it is stated that differences have been observed in the rubber-yielding properties of the "Muteke" vines, and that in consequence the terms "male" and "female" have been applied to the two varieties. Nothing appears to have been recorded previously regarding such differences in the case of *Landolphia Kirkii*, and further observations upon this point would therefore be of interest. The bushy form of "Muteke" (3) is shown to belong to a different species, *Landolphia parvifolia*, K. Schum., the value of which as a source of rubber is a little doubtful at the present time. It has been stated that this plant does not yield rubber, but, on the other hand, it is included by some authorities among

the species which furnish the so-called "root-rubber" of commerce, and it would be desirable to conduct experiments in Rhodesia to determine this point.

Description of the Rubber.

The sample submitted for examination consisted of about 1·5 lb. of rubber in small balls, each about 1·5 inches in diameter. Two pieces of old rubber obtained from the natives were also forwarded, but these were too small for separate examination, and were not included in the sample selected for analysis. The rubber was light brown, fairly clean and free from stickiness, and possessed good physical properties.

Chemical Examination.

A representative sample of the rubber was examined and found to have the following composition :—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	14·9	—
Caoutchouc (true rubber)	69·1	81·2
Resin	8·7	10·2
Albuminoid matter	1·7	2·0
Dirt and insoluble matter	5·6	6·6
Ash	0·9	1·0

These figures are in general agreement with those obtained in the examination of the previous specimen, and prove that the rubber is of very fair quality. The present sample contains a lower percentage of resin than that previously found, 10·2 compared with 12·5, but owing to the fact that it includes a larger amount of vegetable impurities the percentage of caoutchouc is approximately the same.

Commercial Valuation.

The rubber was submitted for valuation to commercial experts, who classed it as "good clean ball of Nyasaland character," and worth about 3*s.* 10*d.* per lb. in London at the present time, when fine Para is quoted at 5*s.* 7*d.* per lb.

LATICES OF *FICUS COMOSA* AND *FICUS INDICA* FROM INDIA.

THESE specimens of the latices of *Ficus comosa* and *Ficus indica* were forwarded to the Imperial Institute by the Director of the Royal Botanic Gardens, Calcutta, and although the products furnished by these two species of *Ficus* are of little economic value, it may be useful to record the results of the chemical examination. Both specimens had undergone change during the journey, and were more or less completely coagulated on arrival, so that no experiments could be made on the actual latices.

Description of Samples.

LATEX OF *FICUS COMOSA*.—The sample consisted originally of about 200 c.c. of latex, but coagulation had occurred during transit and a quantity of solid material had separated, leaving a slightly milky liquid. Both solid and liquid possessed an extremely unpleasant odour.

The solid matter was removed and dried by exposure on a porous tile, when it formed a dark-brown coherent mass, which was hard and sticky, and weighed about 20 grams. When placed in warm water it became soft and sticky, but returned to its hard condition on cooling.

Experiments were made with the fluid portion of the sample, but no further coagulation could be induced by any of the usual methods.

LATEX OF *FICUS INDICA*.—This sample had undergone coagulation, and was quite solid on arrival. The substance was dried by exposure on a porous tile, and was obtained as a buff, friable material, which became soft and somewhat elastic on immersion in warm water but hardened on cooling.

Results of Examination.

The following figures give the results of the chemical examination of the dry materials:—

	Ficus comosa. Per cent.	*Ficus indica.* Per cent.
Resin	82·6	79·1
Caoutchouc (rubber) . . .	9·9	7·3
Insoluble matter	7·5	13·6
Ash	1·1	1·4

These results show that both products consist essentially of resin; and the small percentage of caoutchouc present was of very poor quality, being soft, sticky and deficient in elasticity and tenacity.

GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

AGRICULTURE AND COTTON CULTIVATION IN CYPRUS.

IN the spring of 1904, at the request of the Secretary of State for the Colonies, Professor Wyndham Dunstan, F.R.S., the Director of the Imperial Institute, visited the Island of Cyprus, and after inspecting the chief districts and meeting the principal native cultivators and merchants, reported on its general agricultural condition, and especially on the prospects of cotton growing, and made recommendations as to the best means of developing the resources of the island. The present article gives a brief account of this report, which, together with a map of Cyprus and correspondence with the British Cotton Growing Association, has been published as a Parliamentary Paper [Cd. 2717 of 1905].

The wealth of Cyprus is at present principally derived from agriculture. The area of the island is rather more than 3,500 square miles, of which it is estimated that about 1,700 square miles are at present under cultivation by small proprietors, whilst at least 700 additional square miles are capable of being cultivated. The population, partly Turkish but chiefly Cypriot and Greek, is rather less than one-quarter of a million.

In the Middle Ages cotton was a staple product of Cyprus, and the variety there produced was much esteemed, the annual export during the Venetian occupation amounting to from seven to fifteen million pounds. In the seventeenth and eighteenth centuries the English Levant Company sent large quantities from Cyprus to England. When the scarcity of cotton occasioned by the American Civil War gave a stimulus to its growth in all countries possessing suitable climates, Cyprus took part in

meeting the demand, and in 1866 over 2,000,000 lb. were exported. Since then production has declined.

The possibility of growing cotton in the island thus needs no demonstration, but at present the industry is not of any large dimensions, the average production not exceeding 1,000,000 lb. It is estimated that recently, at the most, about 4,000 acres have been under cotton cultivation, whilst in Venetian times about 60,000 acres must have been required to furnish the cotton exported, and probably nearly an equal area was devoted to growing that manufactured locally into cloth for export and to meet the needs of the population.

Cyprus, excluding a singular promontory at its north-east corner, known as the Karpas, is about 100 miles long, and from 30 to 60 miles broad. The Karpas stretches out into the sea for 40 miles, having a width of only 6 or 7 miles. A range of mountains runs east and west along most of the north coast; to the south of this range lies the plain of Mesaoria, which is 60 miles long and from 10 to 20 miles broad. South of this again is another mountain range, also running east and west and sloping down to the south coast.

Cyprus is situated near the isothermal line of 68° F.; the general temperature varies from the moderate cold of 40° to 60° in winter to the heat of the summer sun in the plains, when the temperature reaches 100°. The rainfall is small and uncertain; it never exceeds 40 inches in the year, and may be below 10 inches; nearly all of it falls in the winter months.

Cotton cultivation, as at present practised, is of two kinds, which may be described as "dry" and "wet" respectively; they produce different qualities of cotton. The "dry" cultivation is employed chiefly in the Mesaoria and in the Karpas. The seed is sown broadcast or else in trenches; the plan of sowing it in ridges customary in America and in Egypt apparently has not been adopted. The sowing takes place from the middle of April to the middle of, or even the end of, May. The young plants are thinned out after they have sprung up. The "dry" cotton receives one or two waterings, and depends mainly on the winter rain retained in the soil. Practically no rain falls in Cyprus from the time the seed is planted until after the crop has been gathered, and irrigation is the only means of supplying

water to the fields, the water being usually derived from wells, or in a few instances from running streams.

The "wet" system is confined to a few districts where sufficient water can be obtained from springs to allow periodical waterings of the fields; these are given about once a fortnight from the time the plants have appeared until the bolls have formed. The water is raised by means of primitive water-wheels, the "alacati" resembling the "sakia" of Egypt, in which the water is carried in jugs attached to the rim of a large wooden wheel made to revolve by an ox or a donkey. This pump is capable of improvement, and an improved form in iron has been recently introduced. In the neighbourhood of towns air motors of the American windmill pattern are also coming into use. The plough in general use is of primitive construction, and is made of wood, but light iron ploughs are occasionally seen.

In the "dry" cotton fields manuring is rarely practised, but on the watered fields farmyard manure is often applied; the use of chemical manures appears to be unknown. Rotation of cotton with cereals is usual, but the crop grown in the rotation appears to be selected more on account of its intrinsic value than for its effect on the soil and influence on the succeeding crop of cotton.

The cotton is gathered in the latter part of September or in October, and sometimes as late as November. In many districts it is treated as a perennial, and a crop is gathered in the second and even in the third year. It is alleged by some cultivators that the second year's crop is superior to the first. The picking is chiefly done by women; the ginning is usually effected by roller gins of Platt's manufacture, which are to be found in the principal villages of the cotton districts. At Larnaca, a port on the south coast, the cotton is baled by means of hydraulic presses.

As regards the varieties of cotton grown, that sown on the "dry" lands appears to have been derived from a native variety (*Gossypium herbaceum*), improved by cultivation in former times.

At the time of the American Civil War, "Orleans" seed was introduced and did well, especially on irrigated land. Egyptian

seed is generally regarded as unsuitable, but has not been systematically tried. It appears that in some districts a hybrid between the American and the native variety has been produced, and also that degeneration of the cultivated cotton has occurred very extensively. It is, in fact, no longer possible in some cases to distinguish with certainty between the native cultivated cotton and the American variety. Irregularity in the length of staple is often exhibited. The "dry" cotton is harsh to the touch and short in staple, but of satisfactory colour; it is valued at about one half-penny a pound less than the "wet" cotton. The latter is usually of longer staple and of finer quality; in Marseilles and Trieste it obtains a rather better price than ordinary American "Upland," ranking next to the "Jumel" cotton of Egypt.

The seed for sowing is either collected locally, apparently without special selection, or purchased from seed merchants in America, and there is great need for the farmers to pay particular attention to securing good seed.

The amount of ginned cotton obtained per acre is high, often amounting to 450 lb. or more, which is equal to the average produced by careful cultivation in Egypt; from 250 to 300 lb. may be regarded as a low estimate for the average yield, which is thus far higher than the average yield in America of about 180 lb. per acre.

The following is an approximate estimate of the cost in the Mesaoria of cultivating a Cypriot donum, and of preparing the cotton for export; the donum, the unit of land measure, is a somewhat variable quantity, but it may be taken as from one-half to three-fifths of an acre; an oke is equivalent to 2·8 lb.

	£	s.	d.
Two ploughings	0	5	0
Eight okes (22·4 lb.) of seed	0	4	0
Sowing	0	2	6
Two waterings	0	1	0
One hoeing	0	1	0
Picking 200 okes (560 lb.) of cotton	0	2	0
Transport and ginning	0	5	0
Transport of 60 okes (168 lb.) of ginned cotton to Larnaca	0	2	0

Baling 60 okes	0	1	0
Government tithe	0	3	6
Wharfage, shipping dues . .	0	1	0
Total	£1	8	0

This total is exclusive of rent of land, of any charge for the water used, and for manuring.

The approximate return to the cultivator may be calculated as follows:—

	£	s.	d.
Sale of 60 okes (168 lb.) of ginned cotton at 1*s.* per oke (2·8 lb.) .	3	0	0
Sale of 140 okes (392 lb.) of seed at 15 paras per oke . . .	0	6	0
Total . .	£3	6	0

The profit to the cultivator, exclusive of land, manure and water charges, is thus £1 18*s.* per donum, or about £3 15*s.* to £4 per acre; this profit can be made under favourable circumstances, but in several places the average profit is lower. When the cotton is regularly irrigated the cost is higher.

The cultivator considers 1*s.* to 1*s.* 4*d.* per oke (4*d.* to 5*d.* a lb.) a remunerative price for ginned cotton. The cotton seed is not pressed for oil, but is nearly all used locally as cattle food.

An appreciable quantity of the cotton produced remains in the Island, being employed in making native cloth. In most villages yarn is twisted by hand and cloth is made with a primitive hand loom.

As regards the prices obtained, the first quality of Cyprus cotton, described as "Irrigated and grown from American seed," is stated to have been sold in 1904 in Marseilles for between 6½*d.* and 6¾*d.* per lb. The second quality, described as "American non-irrigated dry," sells for about 10 per cent. less than the first quality. The third quality, "Native non-irrigated," is almost entirely consumed locally; it is usually of short staple, somewhat discoloured and stained, and often contains fragments of boll. Samples of "wet" and "dry" Cyprus cotton were

valued in Manchester in 1904; the "wet" cotton was described as being very bright and clean, of a class equal to "Middling fair American," resembling East Indian cotton in that the staple was very short, and the quotation for it was given as $6\frac{7}{8}d.$ per lb., being about the same as for "fine broach." The "dry" cotton was of rather longer staple than the "wet," but of a lower grade, and was valued at about $6\frac{1}{4}d.$ per lb.

Cyprus cotton goes to Marseilles and Trieste rather than to England, the transport service to England being uncertain and the charges much higher; the freight to Marseilles is about 25*s.* per ton, to Trieste about 15*s.*, whilst that to England is usually about 50*s.* Further, there is a greater demand for short-stapled cotton in France and Austria than in England, and higher prices are usually obtained for Cyprus cotton in those countries. Samples of the cotton of Cyprus, together with an account of the cultivation, were shown at the Exhibition illustrating British Cotton Cultivation, which was held at the Imperial Institute in June 1905. (See this vol., p. 113.)

Since the year 1878, when the British Government undertook the administration of the Island, transport and communication has been rendered easy by the construction of an excellent system of roads, so that cotton can be cheaply transported from the interior; and the light railway now constructed from Famagusta on the east coast to the capital Nicosia will afford further carriage facilities.

The agriculture of the Island, however, is in an extremely primitive state, and if the wealth of the inhabitants is to be increased, the farming methods must be modernised, and the farmers induced to enter intelligently into the adoption of improvements. To effect this one of the most important steps would be the creation of a well-organised and well-equipped Agricultural Department, with experimental fields on which trials could be made to determine the varieties of plants and the modifications of agricultural practice which are best suited to the soil, climate and conditions of the Island. Some work has been done already in this direction by the Agricultural Department, established in 1896, but its scope is at present only small, and it requires considerable enlargement.

If methods of cultivation based on the results of experimental

trials are adopted, and if an adequate supply of water can be provided, the cotton-growing industry can be re-established and made the foundation of the future prosperity of the Island.

Owing to the small and uncertain rainfall water must be provided for the fields by irrigation. The present reservoir system is inadequate and needs extension. The rivers of Cyprus are mountain torrents, and although during the winter these water-courses are full to overflowing, in April and throughout the summer they are for the most part dry. In several localities excellent springs of water are running throughout the year, and in such districts irrigation is possible and the best cotton is grown there. In most districts, and especially in the Mesaorian plain, a supply of water in spring and summer can only be obtained from wells, and in many cases these must be sunk to a considerable depth to be at all efficient. In some places large supplies of underground water exist, and attention should be given to rendering these available. The possibility of obtaining water by sinking artesian wells also requires trial. On the one occasion when bores were made, they do not appear to have been carried to a sufficient depth.

Every inducement should be given to the natives to find water and sink wells ; improvements, too, in the method of raising water to the surface should be tried. There is little doubt that in Venetian times, when the cotton industry of the Island was most flourishing, the necessary water was chiefly obtained from wells sunk by the natives. The disappearance of nearly all the forests of Cyprus, and the comparatively treeless condition of a large area of the Island, has had a prejudicial effect on the rainfall ; and the judicious planting of trees in suitable districts should be vigorously proceeded with.

The time of sowing the cotton seed at present adopted seems unnecessarily late, and may have been chosen chiefly in order to avoid the attacks of locusts, which are now no longer to be feared. To this subject, and also to the question of growing a better class of cotton in rotation with other crops, the experiments of the Agricultural Department should be directed. If a better quality of cotton, such as Egyptian cotton of medium staple (about $1\frac{3}{8}$ inches), were produced, and if a regular transport service to England were instituted, Cyprus cotton could take part in

supplying the needs of the English mills, and the cultivator would receive increased remuneration.

The other agricultural industries of the Island, which include stock-raising, the growth of carob or locust beans (*Ceratonia Siliqua*), of barley and other cereals, and of fruit, the preparation of raisins and the production of wine and of silk, all need development, and would benefit by the establishment of a proper Agricultural Department.

The improvement and extension of the native industry must be the first step towards the extension of cotton cultivation in Cyprus. At present there appear to be only a few thousand acres of irrigated land suitable for cotton growing that are not already secured; but if a satisfactory system of obtaining water for irrigation were established, Cyprus would become a splendid field for agricultural enterprise, and should attract the attention of British capital. The climate is well suited to the European temperament, there is ample room for a large additional population; and besides the English and European markets, Egypt affords a promising field for the profitable sale of live stock, fruit and vegetables.

In former times Cyprus was the scene of great activity in mining, the copper ores of the Island being known throughout the world. No trustworthy information is on record with regard to the mineral deposits which exist at the present time, and until this information has been obtained no opinion can be expressed as to the possibilities of mineral development.

COTTON CULTIVATION IN THE UNITED STATES OF AMERICA.

THE cultivation of cotton in the United States has been studied recently by Mr. Gerald C. Dudgeon, Superintendent of Agriculture for British West African Colonies and Protectorates, who has just returned from a visit of inspection to the cotton-growing districts of that country. The following is a brief account provided by Mr. Dudgeon of the more important points in his report. A series of specimens collected by Mr. Dudgeon is now on view in the Cotton Exhibition in the North Gallery of the Imperial Institute.

1. *Cotton Soils and the Methods of Preparing them for Cultivation.*

There is a great diversity in the character of soils in the Southern States in which cotton is successfully grown. Of course the quality, or even the variety of the crop grown, is not dependent entirely upon the soil, but is in a great measure influenced also by the elevation, proximity to the sea, and the climatic conditions. But, taking a glance at the formation of the soils alone, it may be justly said that they vary from very sandy loams to fairly stiff clayey deposits. Perhaps the most sandy are found in Southern Georgia, where the forests are under sluggish running water for the greater part of the year, and where, after a heavy rainfall, much of the cultivated land exhibits a fine grey sandy silt. In this part of the country Sea Island cotton is chiefly cultivated. In Arkansas a different form of sandy soil was observed; here the sand is of coarser grain and reddish, but the soil does not appear to be inferior to that of South Georgia. Owing doubtless to its greater elevation and distance from the sea, only Upland cotton was found. In South Carolina, in the Uplands at Bennettsville, the ground appeared quite white with the sand remaining on the cultivated fields after rain. The soil itself is not very poor, although requiring a large quantity of chemical fertiliser to make it yield a good crop. Less sand was visible in the South Carolina islands, South Carolina sea-board, and Middle and Lower Texas regions, and still less in the red hills of Georgia and the Brazos river-bottoms of Middle and Lower Texas. The soil of the prairie land of Upper Texas is stiff and black, quite unlike any of the others, and in consequence can only be ploughed in dry weather.

The opinion of planters in the older States, and where the sandy lands chiefly occur, is that some crop is required to precede the planting of cotton in opening up new areas. The reason given for this is not that new lands would be unsuitable for growing the crop, but that the cultivation of cotton is difficult where the soil is not free from roots and foreign matter, much of which would decay and disappear if a maize or a potato crop were taken off in the first instance. Practically

no new lands have been opened up recently in Bennettsville, S. C., so that the suggestions by planters here cannot be regarded as so important as those made in the low Georgia districts, where new land is brought into cultivation from the pine forest each year. The cotton cultivated in these latter districts is almost entirely of the Sea Island variety, and one planter recommends that it should be preceded by three years cultivation of other crops. His system is to burn the pine stumps and roots after felling the trees, to plough the land to eight inches in depth, and to remove the roots from it by means of a harrow, after which he puts in the following crops:—

1st year, sweet potatoes;
2nd year, sweet potatoes, peanuts or Irish potatoes;
3rd year, oats, with or without cowpeas or velvet bean;
4th year, cotton, with 400 lb. of chemical fertiliser per acre;
5th year, cotton or maize and cowpeas; if cotton, then also 400 lb. of chemical fertiliser;
6th year, whichever of the two last crops was not grown in the fifth year.

Another farmer in the same district only puts in oats in October of the first year and reaps them in the following May –June, after which he grows either maize with cowpeas or else cotton manured with 250 lb. of chemical fertiliser. No artificial drainage seems to be employed here, whereas at James Island, where the finest quality of Sea Island cotton is grown, the drainage system is the first matter attended to in opening up new lands. In this island, oats with cowpeas are put in in the first year, and are followed by cotton manured with 1,000 lb. of chemical fertiliser in the second year. In the third year, maize and cowpeas are recommended, to be followed by cotton in the fourth year. In the Uplands of Georgia, where the soil is stiffer and red, the crops preceding cotton are as follows:—after clearing the land, 1st year, oats and cowpeas; 2nd, maize and cowpeas; 3rd, cotton, with 567 lb. per acre of chemical fertiliser. A slightly different rotation is adopted in Alabama, where the same kind of soil is found. Here maize in the first year is followed by oats with cowpeas, velvet bean or vetch in the second year, and in the third and fourth years cotton is grown, manured with 488 lb. of chemical

fertiliser. In Texas, where no fertilisers or leguminous assistant crops for cotton are used, the prairie lands are burned and ploughed, and cotton is put in year after year without intermission. In this State, except in the poorer, sandy, undulating land, the soil is rich and contains all the necessary plant food in such abundance that no artificial assistance is yet needed.

2. *Varieties of Cotton.*

In the islands of South Carolina and in Southern Georgia, up to a distance of sixty miles from the sea, Sea Island cotton is general; it is also found in small tracts of the country further south, and was, at one time, grown in Texas. It may be said to have completely disappeared now from this latter locality in favour of the Upland variety, and is practically confined to the two districts first-named. Sea Island cotton, apparently, is not planted in the stiffer soils; it requires a sandy loam combined with a very humid atmosphere and rather heavier rainfall than is necessary for the Upland variety.

The Upland cottons may be broadly divided into the long- and short-stapled, the former requiring more of the conditions of the Sea Island variety, whereas the latter are grown quite successfully in stiff soils. The long-stapled Uplands are practically only found in the Arkansas and Mississippi river valleys, where the soil is light and the atmosphere is loaded with moisture.

The best conditions for growing cotton in the United States with regard to rainfall and temperature may be said to be nearly the same for all the different varieties. Before the seed is sown, it is necessary that the frosts should be completely over. It is also desirable that heavy falls of rain should not take place soon after the seed is in the ground. If such rainstorms occur in the sandy districts, they apparently do not harm the young plants so much as they do where the soil is stiffer. This is because the water drains more quickly from the sandy soils, whilst the heavy soils retain it for so long that the young plants are killed. In the latter case the fields have to be re-sown, and sometimes even a third sowing is rendered necessary. It is generally conceded that an evenly-distributed rainfall throughout the year is better suited to the requirements of the crop than an uneven one, but that rain is less welcome in the autumn from the

commencement of the picking season on account of the damage a heavy fall does to the ripe cotton. The temperature should average from 65° minimum to 85° maximum during the period of growth, and the later the occurrence of the killing frost the later may the fruiting continue. On the other hand, the earlier the appearance of warm weather in the spring the earlier the crop may be sown. The cotton plant is badly affected by very hot sun just after heavy rain, and often becomes blistered or burnt up from this cause, but is unaffected by great heat when the leaves are free from adherent water.

3. *Manures.*

Manures are used extensively for cotton-growing in the older States, but are not employed in Texas, where the soil is still so rich in plant foods that there is as yet no sign of diminution in yield. So much is this the case that not even leguminous crops are grown to any marked extent, and cotton has been planted without any rotation or rest for a number of years. In the older States, chemical fertilisers, containing soluble phosphate, potash and nitrogen, are applied to the soils. The proportions are from 7 to 11 per cent. of acid phosphate, 3 to 7 per cent. of potash, and 2 to 4 per cent. of nitrogen. In addition to this, cotton is grown in a two- to four-year rotation with oats or maize and leguminous crops (cowpeas, beans or vetches); the latter supply an additional amount of nitrogen to the soil. There is no rule followed for the proportions of the chemicals used in any particular soil except in the Experiment Stations, where the analysis of the existing soil affords a guide to the requirements.

4. *Crops Grown in Rotation with Cotton.*

In most of the States north of Texas some form of rotation seems to have been found necessary, but none is observed in Texas itself. In South Carolina, in the sandy and loamy Upland districts, the following three-year rotation is generally adopted :—

1st year, oats sown in October (previous year) and cut in May–June, cowpeas being grown in the stubble for the rest of the season;

2nd year, maize, with cowpeas, soy bean or velvet bean, the latter being allowed to climb on the maize stalks;

3rd year, cotton, manured with 250–800 lb. of chemical fertiliser

In the Sea Island districts (islands of South Carolina) the land is often left fallow for one year, as in the following rotation :—

1st year, fallow, or oats and cowpeas grazed by cattle or cut for hay ;

2nd year, cotton, sown at the end of March and manured with 1,000 lb. per acre of chemical fertiliser ;

3rd year, maize, with cowpeas ;

4th year, cotton, with a similar application of fertiliser.

It will be noticed that cotton is grown every two years. In the sandy low lands of Georgia, where Sea Island cotton is grown twice in five or six years, sweet potatoes, Irish potatoes or peanuts are sometimes put in for one season. In Alabama the farmers generally practise a three-year rotation, in which cotton is grown for two years and a crop of maize and peas in the third year.

The chief leguminous plants used in all these districts are cowpeas, velvet bean, soy bean and vetch. Japan clover (*Lespedeza striata*) grows wild in Arkansas, and establishes itself in land which is left fallow for some years. It is a useful plant, and might be advantageously used, the root nodules being largely developed.

5. *Seed Selection.*

Apart from the custom of purchasing a small quantity of seed from neighbouring plantations where the crops appear good, and planting the whole of the second season's crop from the descendant seed of that purchase, there is practically no regular system of seed selection among the farmers. In a very few cases, when labour is plentiful, experienced hands may be sent in front of the regular pickers to pick from selected plants which show a heavy crop. No regard is paid to length of staple. There is of course an intricate system of selection of seed carried out by the Agricultural Department's men and the State Experimental Farms, but this receives very little attention from the farmers. The above remarks apply to all the cotton grown on the mainland ; but in South Carolina islands, where the finest Sea Island cottons are produced, there is said to be a carefully worked out secret system.

Many of the poorer and less careful planters are quite content to take any unbroken cotton seed from the gins, and very few know the names of the varieties they are growing. The Texas

planters buy special varieties from the seed merchants, but probably cannot always rely on the seed thus obtained. Others purchase early-fruiting or storm-proof varieties from the advertisers of these kinds.

There is no attempt made to prevent hybridisation from outside plants except at the experimental farms, where occasionally the outer rows of a plot are not picked for seed. Dr. Webber, of the Bureau of Plant Industry, U. S. Department of Agriculture, estimates that the flowers of cotton are 95 per cent. self-fertilised, and that, in consequence, it is scarcely necessary to isolate plants.

6. *Systematic Production of Hybrids and the Prevention of Degeneration in Standard Types of Cotton.*

These operations may be said to be entirely confined to the experimental farms in the different States. The following method is adopted for effecting artificial hybridisation by cross pollination. The stamens of the prospective female parent flower are carefully removed, and the flower is then covered with a paper bag; the male parent flower is permitted to open under the cover of a paper bag, and when ready is uncovered and used as a brush to fertilise the female flower. A number of very interesting varieties have been produced in this way, but it seems to be generally accepted that artificial hybrids are so difficult to keep constant in future generations, that more reliance is placed upon natural divergences for the establishment of new and improved varieties. Still, it is admitted that the long-stapled Upland cottons of the Mississippi Valley were probably produced originally by an artificial crossing of Sea Island with Upland cotton. The only method employed for the prevention of deterioration of standard types of cotton is the careful and constant selection of plants for seed by the Agricultural Department and the officers of the State Experiment Farms. This process of selection is carried out every year, the seed from the best plants in the field being set apart for the further improvement of the type.

7. *Insect and Fungoid Pests which Attack Cotton and the Preventive Measures Employed.*

The most serious insect pests occurring in the cotton States are undoubtedly, in order of their importance, the Mexican boll

weevil (*Anthonomus grandis*), the boll worm (*Choridea* (*Heliothis*) *obsoleta* (*armigera*)), the caterpillar, or cotton army worm (*Aletia* (*Alabama*) *argillacea*), cut worms (*Feltia* and *Agrotes species*), several species of sapping bugs and two species of locust.

The Mexican boll weevil is at present confined to Texas and a little further north, but is fast spreading. There is no method known for its extermination, although the picking up and burning of the early fallen flower squares and the encouragement of the cotton army worm to strip the leaves from the plants in the autumn, thereby allowing the heat of the sun to destroy the weevil larvæ in the bolls, serve to minimise the effects by reducing the numbers. The planting of an early fruiting variety of cotton, and the destruction of all old cotton stalks in the winter, also assist in the same direction.

The boll worm is occasionally very destructive in the older States. Repeated applications of Paris green serve to check the pest, although, from the fact that the larvæ feed with half of their bodies concealed in the bolls or flower squares, it is less easily reached by the poison than is the army worm. Another method of dealing with the boll worm is by planting "trap crops" of maize between the rows of cotton plants. The insects prefer the young maize to the cotton, and therefore collect upon it. When the maize is infested sufficiently it is cut down and destroyed.

The army worm is poisoned with Paris green which is sprinkled on the plants after rain, but the Texas farmers do not try to exterminate broods of this insect when they appear in the autumn as, by stripping the leaves from the mature cotton, the worm does no harm to the plant but allows the sun to get at the bolls, destroying the boll weevil grubs in them, as well as hastening the ripening of the cotton.

Cut worms destroy the young plants when they first come up, and as the many species known are all night-feeders, hiding by day beneath fallen leaves, they are successfully killed by spreading cabbage leaves sprinkled with Paris green between the rows of cotton plants.

The other insects which attack cotton are of less importance as they appear to be confined to small areas.

Among the fungoid pests which attack the cotton plant,

perhaps the "root rot" (*Ozonium sp.*) and the "wilt" (*Neocosmospora vasinfecta*) are the most serious. "Root rot" occurs very severely in the black waxy lands of Northern and Central Texas, and less so in the other prairie lands. No remedy has yet been found for it.

The "wilt" disease is prevalent in the Sea Island farms of South Georgia, where large fields of cotton and cowpeas are affected by it. The Agricultural Department has been successful in establishing wilt-resistant strains of both these plants, and in farms where these strains are used the effects of the wilt disease are no longer seriously felt.

"Boll rot" (*Anthracnose*) appears in some of the best cultivated fields in South Carolina and Alabama and seems to be well known, although in the former State the disease is not attributed to a fungus but to an insect.

"Black arm," an affection appearing upon Egyptian cotton at Blackshear, Ga., has not been identified as a fungoid disease, but is considered by Dr. Galloway to be a physiological condition due to the unsuitability of the soil and climate to the plant. The appearance of dark patches on the stems and bolls of the varieties of Egyptian cotton grown at Blackshear is succeeded by the early death of the plants before all the fruit has ripened. None of the Sea Island cotton growing in the proximity of the Egyptian is affected, nor does the disease seem to have been noticed elsewhere.

8. *Cultivation of Egyptian Cotton in the United States.*

The attempts to grow Egyptian cotton in the United States have not been attended with much success. During recent years several planters have grown it, but only very small yields have been obtained. At the Blackshear Experimental Plantation in South Georgia, the four varieties, "Abassi," "Ashmouni," "Yannovitch" and "Mitafifi," have been grown under various forms of manurial treatment. At another plantation a hybrid between Sea Island and Egyptian cotton has been cultivated. As already stated, all the Egyptian cottons and the hybrid were badly affected with "black arm." The disease on the Egyptian cotton was so severe that the prospective yield of each variety was rendered insignificant. So little success has attended these attempts to

grow Egyptian cotton in the States that Mr. Orton, the noted pathologist to the Bureau of Plant Industry, U. S. Department of Agriculture, is said to have expressed the opinion that there is no hope of its being extensively cultivated.

9. *Recent Improvements in Ginning and Baling and the Use of Machinery for Picking Cotton.*

Several improvements in saw gins have been made recently in Texas, which are chiefly directed to the prevention of waste in the conveyance of the cotton to the presses and from the carts. The use of a condenser before pressing enables the cotton to be fed evenly into the press in the form of a folded bat, and prevents it from flying about. The cylindrical lap bale is regarded with favour, but the fact of its non-adoption upon a large scale in the United States is said to be due to the strength of the opposition brought to bear by the makers and proprietors of the hydraulic compresses, which would no longer be required if the lap bale system were generally established. Sea Island cotton is not usually pressed into such tight bales as Upland cotton, but after being exposed to the sun for some time, it is generally packed in bags of 300 lb., and pressed by hand screw-presses. The fibre is supposed to be liable to so much damage from the action of the compress that the loose packing is preferred.

With regard to cotton-picking machinery it appears that no really practical machine has been yet invented. Lowrie's machine, which is the only one from which good results can be obtained, can only be used in specially widely planted fields and at such times as the ground is sufficiently hard to allow the heavy weight of the four men riding on it to be supported without sinking in.

10. *Conditions of Labour and Tenancy.*

In order to diminish the trouble of supervision, the landholder usually leases as much of his land as possible to black or white tenants. The terms most in favour are those known as the "half-crop system." According to this plan, the tenant is engaged by the year, receives about 30 acres of land and a house, and shares the cotton crop equally with the landlord. In districts where chemical fertilisers are necessary, the tenant bears half their cost, except in cases in which he cannot afford to do so, when the

landlord pays for the whole and takes two-thirds of the crop instead of one-half. When rotation crops of maize and cowpeas are grown, the usual arrangement is for the landlord to receive one-third of these crops, and for one-third to be reserved as fodder for the ploughing mule which is supplied by the landlord. The system varies, however, in different districts.

In some cases, the tenant leases the land outright at a rental of about $5 per acre, receives a house but no other assistance, and is free to grow any crop he wishes and to dispose of it at his own discretion.

The monthly wages for hired labour on the cotton farms vary from $12 to $21, but this system of working is so expensive that it is seldom practised.

Labour is sometimes required in the spring for "chopping out" or hoeing, and is generally obtainable at from 50 to 75 cents per day. During the cotton-picking season, when a large number of hands are required for a short period, from 40 cents to $1.25 per 100 lb. of seed cotton is paid for Upland cotton and $1.00 and upwards for Sea Island.

The black labourer is not available in many districts, and is not sought after in some others, cotton being grown well by European labour. Large colonies of Italians, Poles, Swedes and Germans are settled especially in Texas, and make fair farmers. Except in a few places where respectable and industrious black families have been established for a long time, the negro labourer is not to be depended upon, often leaving his crop altogether unattended to if he experiences any slight misfortune owing to weather or blight. The landowner loses heavily in these cases as he relies on the crop to pay him his rent, and often cannot get another man to take up the land and finish the work for the season. It will be seen that by the "half-crop system" of working, both landlord and tenant having an equal interest in the crop produced, the former is in close touch with the working and is dependent upon its success.

All land in the old States has been held by private owners for a long period, and no revenue is paid to the State. Sales are made by private contract, and simply registered in the courts. In Texas some parts of the country are not yet taken up, but can be bought outright from the State at different rates. The

purchase money is payable in instalments, extended if necessary over 40 years, but the whole amount is usually earned so quickly that the purchaser is enabled to pay for his land completely in a few years. Large grants of land were made to the railway companies in Texas on the condition of their extending their lines, which they have done to the great benefit of the country.

UTILISATION OF MANGROVE BARK.

THE name "mangrove" was applied by Lindley to the trees belonging to the natural order *Rhizophoraceæ.* These trees or shrubs inhabit the muddy swamps close to the sea-shore in tropical climates, where they frequently form forests of vast extent. The mangroves are of particular interest, owing to their peculiar habit of growth, which is described by Hamilton as follows:—"In the economy of nature the mangrove performs a most important part, wresting annually fresh portions of land from the dominion of the sea. This is effected in a twofold manner, by the progressive advance of their roots and the aërial germination of their seeds, which do not quit their lofty cradle until they have assumed the form of actual trees, and drop into the water with their roots prepared to take possession of the mud, in advance of their parent stems. The progression by means of the roots is effected by fresh roots, which issue from the trunks at some distance above the surface of the water, and arching downwards, enter the mud. In this manner, the plants, after their descent from the parent trees, continue during their early years to advance steadily forward till they have attained a height of about fifteen feet, and gained a position considerably in advance of their parent trunks. After this fewer additions are made to the roots, but the head begins to expand in every direction, spreading its branches on all sides. These branches in turn send down long slender roots like those of the banyan tree (*Ficus indica*), which, rapidly elongating, descend from all varieties of height, and, reaching the water, penetrate the mud, becoming in time independent trees; thus a complicated labyrinth is formed."

It has long been known that all parts of the mangroves, and

especially their barks, contain tannin, but it is only comparatively recently that mangrove bark has been systematically collected and imported into Europe for the use of tanners.

Mangrove Barks suitable for Tanning Purposes.

The mangroves best known as yielding barks suitable for tanning purposes are *Rhizophora mucronata*, *Rhizophora Mangle*, *Bruguiera gymnorrhiza*, *Ceriops Candolleana* and *Roxburghiana*; and *Kandelia Rheedii.*

Mangroves yielding barks rich in tannin are fairly widely distributed in tropical countries, and in recent years a good deal of attention has been paid to the exploitation of these materials in various countries, notably Germany and Belgium. The best-known mangrove barks in European commerce are probably those of

German East Africa,

which have been made the subject of special study by Dr. Busse (*Chem. Centr.* 1899. I. (4), p. 315), and by Professor Körner, whose analyses are recorded in *Jahresberichte Gerbschule*, Freiberg, 1899–1900.

These results show that the richest mangrove barks obtainable from German East Africa are the "Mkaka," derived from *Rhizophora mucronata*, which may contain as much as 48·0 per cent. of tannin, though samples containing only 21·3 per cent. were examined. The "Msinzi" bark, derived from *Bruguiera gymnorrhiza*, contained from 44 to 53 per cent. of tannin, whilst the "Mkandaa" and "Mkamavi" barks, obtained from *Ceriops candolleana* and *Xylocarpus granatum* respectively, contained 42·3 and 40·5 per cent. of tannin. Quite recently a similar series of barks from

Zanzibar

was examined at the Imperial Institute, and the results, which were given fully in the *Bulletin of the Imperial Institute*, 1904, Vol. ii., p. 165, showed that the "Msinzi" bark of Zanzibar contained 35·8 per cent. of tannin, and the "Magomi" and "Mkomafi" barks of Pemba, 32·8 and 23·8 per cent. of tannin respectively. These East African barks seem, on the whole, to be richer than those of

India and the East Indies.

A series of mangrove barks and extracts prepared in India was examined at the Imperial Institute in 1899, and the results are given in *Technical Reports and Scientific Papers*, Part 1, p. 186. For the present purpose it is, perhaps, sufficient to recapitulate briefly the amounts of tannin found in the various barks—*Rhizophora mucronata*, 4 to 27·29 per cent.; *Bruguiera gymnorrhiza*, 12·77 per cent.; *Ceriops Candolleana*, 13·23 to 21·54 per cent.; *Ceriops Roxburghiana*, 23·54 per cent.; and *Kandelia Rheedii*, 11·99 per cent.

Some attention has also from time to time been paid to the utilisation of mangrove barks in Ceylon, Borneo and the Straits Settlements, and recently a considerable export trade in mangrove barks, and so-called "mangrove cutch," has arisen in Sarawak and British North Borneo. In the Federated Malay States considerable quantities of mangrove timber are used at present, but the bark seems generally to be thrown away, though in the Dindings, according to the District Officer, some "Tengah bark" (*Ceriops Candolleana*) and "bukan bark," derived from a *Rhizophora* or *Bruguiera*, is used locally, and exported for tanning purposes (*Agricultural Bulletin, Straits Settlements*, Vol. iv., pp. 3 and 124). Barks derived from a *Bruguiera* or *Rhizophora* species, and containing from 19 to 24·3 per cent. of tannin, are also used locally in Indo-China (*Feuille de Renseignments*, 1904, **58**. p. 2). Perhaps the most recent addition to the countries exploiting the mangrove for bark is

Queensland.

A short description of the conditions under which it is collected in this Colony is given in the *Bulletin of the Imperial Institute*, 1904, Vol. ii., p. 276, where it is shown that the Queensland bark contains 39·5 per cent. of tannin. A region celebrated for the extent of its mangrove swamps is

West Africa,

but so far no serious attempt seems to have been made to collect this product for export in any of the West African Colonies. Possibly the reason of this is that the oil palm (*Elæis*

guineensis) is so plentiful, and its products are in such demand at remunerative prices, that there is no incentive to collect less valuable products such as mangrove barks.

Some years ago this industry was started in Senegal by a French firm, but after a short time the collection of the bark was prohibited by the Government, for the reason that the mangrove trees were cut down, with the result that rapid erosion of the foreshore took place. Recently, however, M. E. Baillaud has again directed attention to this subject (*Journal d'Agriculture Tropicale*, 1904, Vol. ii., p. 200), and has given an account of some preliminary experiments made in the collection of the bark by natives in French Guinea.

Collection and Export of Mangrove Bark.

In German and Portuguese East Africa, where mangrove bark has, perhaps, been more systematically worked than elsewhere, the mangroves were at first cut down for timber, and the bark was wasted until its value as a tanning agent was discovered. In the German Protectorate the bark is now stripped from the stems and branches of the living trees, conveyed to convenient centres, broken up, and dried in the sun (or by artificial heat produced usually by the combustion of mangrove timber), and exported.

The industry is under the control of the Forest Department, which insists on the bark being carefully stripped, so that the trees are not destroyed (stripped trees are said to renew their bark in from four to six months), and the authorities also prohibit the export of bark containing less than 45 per cent. of tannin.

In M. Baillaud's experiments much the same plan was followed, and it was found that natives working piece-work could collect about 200 lb. of bark per day, and it was estimated that to place a ton of the bark in Europe would cost fr. 124 c. 50, which seems to be an unnecessarily high figure. It was noticed that if the bark is exposed to the rain after collection, a considerable loss of tannin occurs, so that it is desirable that the drying be conducted under cover when wet weather prevails. In the East Indies the bark is stripped, then dried, and roughly ground and packed in small bales, sometimes under pressure.

In this way the cost of transport to Europe is reduced somewhat. Allusion has also been made to the fact that the authorities in German East Africa prohibit the export of bark containing less than 45 per cent. of tannin, and where such regulations are not officially in force, it would be well for exporters to adhere to this rule, since tanning materials are now almost universally bought on their actual content of tannin, and mangrove bark containing less than 45 per cent. of tannin is scarcely saleable, and the inclusion of such material with good bark might lead to losses.

But little attention has as yet been paid to the utilisation of mangrove timber. M. Baillaud states that it is, as would be expected, peculiarly resistant to the action of water, and is therefore suitable for the construction of piles, railway sleepers, and similar articles where hardness and great resistance to the action of water are of importance. It has also been used for street paving in Paris, but apparently the price obtainable for it for this purpose did not prove remunerative.

In the countries where mangrove bark is principally produced at the present time, skilled labour is not usually available, and consequently

The Manufacture of Mangrove Extract

from the bark is difficult if not impossible. There can be no doubt, however, that if the extract could be made in these countries much of the poorer bark at present discarded could be utilised, and as the export of extract would mean that only the really useful portion of the bark would be sent to Europe, a great saving in the cost of transport would be effected. It may be worth while, therefore, to give here a short account of the modern process of preparing tanning extracts from mangrove bark and similar products.

The bark, after being thoroughly air-dried, is ground in a bark mill or disintegrator so as to form a powder, through which water will percolate slowly. This is then packed into "leaches" or extractors, which usually consist of round pine-wood tubs, strengthened by iron hoops and provided with perforated false bottoms, below which the extracting liquor may collect. A series of these "leaches" is employed, a connection by means of a

copper or leaden pipe running from the chamber below the false bottom of each to the mouth of the next. Each is also provided with a pipe, whereby steam can be introduced, so that the extracting liquid may be heated to any desired temperature. Water is allowed to flow into the first extractor of the series, which is then heated by means of its steam jet. The warm water percolating downwards through the ground bark, extracts the tannin and other soluble matters, and the liquor so produced gradually accumulates below the false bottom, and as this fills the liquor is forced by the pressure of the water, which is continually supplied to the first extractor, over into the second extractor, and so on throughout the series, until from the last a comparatively strong liquid is obtained. This is then run into a vacuum-evaporator of the Yaryan or similar type, in which it is exposed in thin layers for a short time to a temperature of about 80° C., whereby it is converted into a thick liquid of specific gravity 1·2. Thence it is run into an ordinary vacuum-pan, and evaporated *in vacuo* to a satisfactory consistence. The process thus briefly outlined yields a satisfactory extract (cutch) for dyeing purposes, but one of the greatest objections to the use of mangrove bark or extract for tanning purposes is, that it produces a leather having an objectionable red colour, and consequently it is necessary in manufacturing extracts for tanning purposes to decolorise the liquor at one stage in the process. This is necessary not only because of the colouring matter naturally present, but also because in the process of manufacture the application of heat to the tannin and extractive matters leads to the production of dark-coloured substances by their partial decomposition. The decolorising process is usually carried out with the liquor as it comes from the extractors, and consists in the addition of small quantities of albumen, alum (or aluminium sulphate) or similar material, which forms an insoluble compound with a small portion of the tannin, and as this settles out it carries with it a great part of the objectionable colouring matters. Bleaching agents such as sulphur dioxide or salts yielding this have also been used for the decolorisation of mangrove and other extracts to be employed for tanning purposes, but none of these methods have so far succeeded in completely and permanently eliminating

the red colour. This is the most serious difficulty in the way of an extension of the use of mangrove bark as a tanning agent, and recently the German Colonial Society has offered a prize of 3,000 marks for a satisfactory and permanent method of decolorisation. The conditions under which this prize is offered are given in *Der Tropenpflanzer*, 1905, pp. 475–6.

The total cost of a small plant arranged on modern lines for the manufacture of mangrove extract, and with a sufficiently large capacity to be remunerative in working, would probably be from £450 to £500.

Quality of Leather Produced by Mangrove Bark.

Reference has already been made to the dark-red colour of the leather tanned by mangrove bark or extract, and to the fact that this colour depreciates its value. Apart from this defect, mangrove-tanned leather when properly made seems to be of fair quality and suitable for shoe leather and similar purposes. On this point Professor Proctor, of the Leather Industries Laboratories of the Leeds University, says that "mangrove bark is now largely used in conjunction with pine, oak and mimosa barks, and that extract prepared from *Ceriops Candolleana* makes a good but dark-red leather;" and Professor Körner, of the Freiberg Tanning School, as the result of his experiments on the value of mangrove extract as a tanning agent, states that "it yields a soft and pliant, workable leather, which, however, possesses an objectionable red colour, which can only be modified sufficiently for commercial purposes by using it in conjunction with myrobalans, valonia, sumach or similar light-coloured tanning materials.

Extent of Trade in Mangrove Bark.

It is impossible to give any exact figures showing the total amounts of mangrove bark and extracts imported into the principal European countries, since these are not separately shown in the returns, but the following statements and statistics seem to show that the demand for mangrove bark and cutch in Europe has in recent years reached a considerable total.

H. M. Consul at Mozambique, in a dispatch in 1904 to the Foreign Office, states that the quantities of mangrove bark exported from the principal ports of Portuguese East Africa

during 1904 amounted to 12,105 tons. These exports seem to have been sent principally to Germany, the United States and Russia, small quantities only being sent to the United Kingdom. In addition to these large exports it is further stated that a large amount of mangrove bark was, at the end of 1904, lying in the various ports awaiting collection, and it was understood that two sailing vessels were being chartered to convey it to Europe, owing to the uncertainty of steamship facilities for the transport of the bark. The value of the bark in European markets at the end of 1904 is stated by the Consul to have been from £4 10*s*. to £6 10*s*. per ton, and he goes on to say that while the demand in Germany was slack, that in the United States and Russia was firm. The cost of collecting, drying and packing the bark in Portuguese East Africa is estimated at from 20*s*. to 30*s*. per ton, including the export duty of 2*s*. per ton. The freight to Hamburg at that time was about 32*s*. per ton.

The Diplomatic and Consular Report on the British East Africa Protectorate for 1902 [No. 2903, p. 13] gives the following statistics of the exports of mangrove bark, known locally as "boriti bark," from that country :—

	Value.
1900–1 . .	£998 14*s*. 8*d*.
1901–2 . .	£908 14*s*. 8*d*.

The export duty on the bark from British East Africa was then 10 per cent. *ad valorem*.

The Diplomatic and Consular Reports for Sarawak, Brunei and British North Borneo, for the period 1898–1903, give the following figures for the exports of mangrove cutch made there. These exports went principally to the United Kingdom.

Exports from Sarawak.

	Piculs.	Value.
1899 . .	1,612·5	£1,197
1900 . .	1,260·0	£1,039
1902 . .	3,488·75	——

Exports from British North Borneo.

	Cwt.
1903 . .	18,000 (estimated)

These figures may be supplemented to some extent by the import returns for cutch in the United Kingdom, which show

that in 1903 269 tons of cutch, valued at £7,149, and in 1904 254 tons, valued at £5,299, were imported into the United Kingdom from British North Borneo. It may be assumed that this was entirely mangrove cutch. Mangrove cutch, as already explained, is principally used by dyers, and it seems to have taken the place to some extent of the true cutch largely produced in North-West India and in Burma, from the wood of *Acacia catechu*.

PRODUCTION OF CAMPHOR.

THE establishment of the camphor monopoly in Formosa and its more recent extension to Japan have led to a considerable increase in the price of camphor, and as a result the attention of many planters in British Colonies and Dependencies, notably India and Ceylon, has been drawn to this product, and a number of enquiries have been received at the Imperial Institute for information relating to various matters connected with the cultivation, production and preparation of this product. In these circumstances it has been considered advisable to prepare a general statement giving such information as is available on the subject, and dealing not only with the naturally produced camphor but also with the manufacture by chemical means of "synthetic camphor" which has recently appeared on the market, and with the "so-called" "artificial camphor" which has been used from time to time as a substitute for true camphor.

The term "camphors" has been applied in a general sense to a group of naturally occurring compounds containing carbon, hydrogen and oxygen, which are related somewhat closely to that class of hydrocarbons known as the "terpenes" of which oil of turpentine is a well-known type. Using the word in this broad sense, "camphors" are volatile substances possessing characteristic odours; they are mostly crystalline solids, insoluble in water but easily soluble in alcohol. Almost all the "camphors" occur in plants, together with the hydrocarbons to which they are closely and probably causally related. Both the hydrocarbons and the oxygenated bodies are volatile in steam, and the process of steam-distillation is often made use of in separating these constituents from the plant substance in which they are found.

In a narrower sense, however, and as a matter of fact in the sense in which the word is ordinarily used, by camphor is always understood the well-known laurel or Japan camphor, the product of the *Cinnamomum Camphora.*

Many references to camphor are found in the writings of the ancients, by whom it was greatly valued as a rare perfume, and it is often included in their lists of costly possessions. The camphor, however, referred to by the earlier Chinese and Arabian writers was probably another variety known at the present time as Borneo camphor or borneol, which is the product of the tree *Dryobanalops aromatica,* and is also found in small quantity in *Blumea balsamifera.* This variety, even at the present time, is almost all consumed in the East, and very little of it finds its way into the European markets. The exact date of the introduction of laurel camphor into Europe is not known, but it was apparently in use and its value as a medicine recognised as early as the twelfth century.

Common, Japanese, or laurel camphor, is the product of the *Cinnamomum Camphora,* an evergreen of the family Lauraceæ, which occurs native along the eastern side of Asia from Cochin China to Shanghai, and in the islands from Hainan to South Japan. The tree is particularly plentiful in the island of Formosa, where it covers the whole line of mountains, which runs from north to south, up to an elevation of 2,000 feet above the level of the sea.

It forms a large and handsome tree which in its native country attains a height of 100 feet, having a trunk two to three feet in diameter. The leaves are of moderate size and laurel-like in appearance, and when crushed smell strongly of camphor; the stem affords excellent timber, much prized, on account of its odour, for making clothes-chests and the drawers of cabinets. The tree is largely planted in Ceylon for ornamental purposes. The camphor is found in all parts of the tree; the relative proportions in different parts appear to be affected by the age of the plant and the district in which it is grown.

Almost all the camphor of European commerce comes from Formosa and Japan, a comparatively small quantity being supplied by China. For many years, in fact to within quite recent times, it was prepared from the wood by a somewhat

crude and wasteful process, but since the Japanese government has taken over the industry in Formosa and established a government monopoly, the processes now in vogue are much more economical. Previously the wood was cut into small chips from the trees by means of a gouge with a long handle, and these chips were then exposed to the vapours of boiling water. The camphor volatilised with the steam, and, on cooling the vapours, the camphor was deposited together with a quantity of oil, water, etc., which were to some extent removed by draining. For this purpose of treating the chips with steam, crude stills were constructed out of the hollow trunks of trees; these were arranged over a furnace, the wood being protected by a coating of clay. Water was poured into this "still" and a board perforated with small holes was luted on the top. The chips were placed in small bundles immediately over the perforations and these were then covered with earthenware pots. A fire having been lighted in the furnace, the water became heated and the steam passing through the chips carried with it the camphor, which was deposited in minute white crystals in the upper part of the earthenware vessel. The camphor thus obtained in a moderately pure condition was removed from the pots every few days. Four stills, each having ten pots placed in a row over one trough, were generally arranged under one shed, and the stills were moved from time to time as the wood in the locality became exhausted. In some cases, however, the camphor was not extracted on the spot, the chips being conveyed to the towns and submitted to a less wasteful process of extraction. In many of the towns metal stills were used and the steam distillate was passed along a pipe—generally bamboo canes were used—into a receiver, which often consisted of a tub in the upper portion of which straw was placed. The camphor condensed on the straw, the oil and water draining off into the lower portion. Recently, however, the methods have been greatly improved, both in regard to economy of production and to the purification of the product.

In the first place, the camphor wood is now submitted to the action of steam over roughly-built, though efficient, furnaces and the camphor is condensed in cooled wooden vessels. It is then freed from the oil by draining, and the product thus obtained is

known as crude or *Grade* "*B*" camphor. For the production of refined or *Grade* "*A*" camphor, the crude material is heated in large iron retorts through which a current of air is passed. For the first 48 hours only sufficient heat is applied to drive off the water and oil; the retorts are then connected to a condensing chamber, the roof of which is cooled by running water, and are heated to a higher temperature to volatilise the camphor. The camphor then collects in the cool chamber in the form of small crystals or "flowers." It is removed, formed into blocks and pressed, first by steam power and finally by high hydraulic pressure. It is then sold as "refined" or Grade "A" camphor.

Camphor Oil.—In all the processes of extraction a considerable quantity of essential oil is obtained, first in the steam distillation and then from the subsequent process of draining. This is known as *camphor oil.* As would be supposed, this contains a considerable quantity of camphor in solution which can be partially recovered by fractional distillation. Many other interesting bodies have been found to be constituents of the oil.

Uses of Camphor.—As before mentioned, camphor has long been known as a perfume and has been extensively used for the prevention of insect ravages in clothing. As a drug it is largely consumed by the natives of India and very large quantities are annually imported into Bombay and other ports. It is also used medicinally in Europe and America; it has antiseptic, sedative and stimulating properties and is frequently applied both internally and externally. It is interesting to notice that it has been recently used, apparently with very beneficial results, by Koch in cases of tuberculosis.

Industrially, it is used on a large scale in the manufacture of celluloid and also in the preparation of smokeless powder. *Camphor oil* has found many and varied applications. It is used by the Chinese as a remedy for rheumatism. Large quantities are worked up annually in Europe for the manufacture of safrol; it is also used in perfuming certain kinds of soaps, and as a solvent, is used in varnishes. Like most essential oils it is a powerful germicide and disinfectant.

Camphor Monopolies.—As long ago as the beginning of the eighteenth century the Chinese government endeavoured to turn the camphor forests of Formosa to account by introducing a

camphor monopoly, the evasion of which was punished by death. In the year 1720 no less than 200 persons were executed for cutting down the trees without permission. This monopoly continued, though in a somewhat modified form, for a century and a half, only being revoked in 1868.

Since the island became a Japanese possession, however, the production and sale of camphor has again become a government monopoly. The monopoly came into force in August 1899. The government granted licences to authorised persons for the preparation of crude camphor, regulated the number of stills so as to control the supply, and built a factory at Turpeh for the purification and pressing of the crude article. The sale prices were fixed and controlled by the Japanese government. In 1900 the government accepted the tender of an English firm to take over the production with a view to putting it on the market. The result was of course that, with the chief supply thus monopolised, the price of camphor was forced up, and in a very short time the price of refined camphor had increased 100 per cent.

As might have been expected, this increased value of camphor stimulated the production in other districts than Formosa, and owing to the fact that the industry in Old Japan was still in the hands of private traders, the Formosan monopoly was greatly hampered in its endeavour to completely control the market. On the appeal of the Formosan government, a bill was introduced by the Japanese Parliament to the effect that the camphor monopoly should be extended to Old Japan, and this was adopted in July 1903. The bill also provides for the inclusion within the monopoly of the production of camphor oil.

The terms of the bill are roughly as follows:—Producers of crude camphor and camphor oil must have a licence for carrying on their trade; they must keep exact accounts of the manufacture and must deliver their camphor products to the Japanese government, for which they will receive compensation at a rate fixed by the government. The producers are not allowed to refine crude camphor, this is the exclusive right of the State.

The government now sells the camphor which it has acquired mostly at a fixed price and reserves the right to restrict the production when the state of the market renders it necessary.

The monopoly in the camphor industry has exerted a powerful

influence on the world's trade in this product, and, as the European demand is continually increasing owing to its industrial applications, the question of the cultivation of the camphor-tree in other tropical regions has been seriously considered. It has already been successfully cultivated in Ceylon, India, Australia, Florida, and California. In a circular published from the Royal Botanic Gardens of Ceylon, Messrs. Willis and Bamber, the Director of the gardens and the government chemist respectively, have laid before the planting public in Ceylon the results of some apparently very satisfactory experiments indicating the methods of cultivation and preparation which had been found best suited to Ceylon.

Camphor Cultivation in Ceylon.—*Cinnamomum Camphora* was first introduced into Ceylon by the Royal Botanic Gardens in 1852. In the autumn of 1893 seeds were obtained from Japan, and the plants resulting from these were in 1895 largely distributed to planters and others in the island. Subsequently Mr. Nock, Superintendent of Hakgala, collected information about these trees (about 950), and reported as follows:—

"During 1895 plants of camphor were distributed from Hakgala to planters in various parts of the island, at elevations ranging from 250 to 6,540 feet, with annual rainfalls varying from 54 inches on 104 days to 217 inches on 212 days.

"Replies as to the growth of the trees have been received from 30 localities, and I think it is pretty well proved that under certain conditions of soil and climate, camphor will thrive at all elevations in Ceylon, from about sea level to the highest mountains.

"It appears to thrive best in a well-drained deep sandy loam in sheltered situations with a rainfall of 90 inches and over, and dislikes poor or close, stiff, undrained soil. The growth is slow in sterile soil, but, under favourable conditions, in good soil is very rapid, the tree reaching a height of 18 to 20 feet in five years, with a spread of branches of 8 to 12 feet and a stem 6 to 7 inches in diameter. This compares very favourably with the growth of the trees in their native habitat, where a tree 30 feet high and 6 inches in diameter at ten years old is considered good. The best five-year-old tree (from planting) in Ceylon is at Veyangoda at an elevation of about 100 feet with a rainfall of about 100 inches

on 180 days. It is 25 feet high and growing luxuriantly. The next best are at Hakgala, where the largest is 20 feet high, with a spread of 13 feet and a stem diameter of 7½ inches at the ground.

"The habit of the trees in Ceylon in good soil is bushy, with a tendency to throw up many stems. This is a point of importance as it shows that the tree will coppice well and stand frequent cuttings and prunings, and possibly even plucking of the 'flush' as with tea. In close, hard, undrained, or stiff clayey soil, the growth is poor and the habit stunted or dwarfed, and this is also the case in exposed wind-blown situations.

"Of course it is only in the experimental stage here yet, but judging from my experience of it for some years, it is my opinion that as a minor product it should be grown in the form of hedges, planted at distances of 6 to 9 feet apart, and 2 to 3 feet apart in the row. The rows should run N.W. and S.E., or across the directions of the prevailing winds, and the plants should be allowed to grow 6 to 9 feet high. Planted in this way there would be ample room for cultivation, and each row would shelter the other from the N.E. and S.W. winds, besides forming a large surface for clipping. As the young shoots appear to yield the most camphor, the crop could be obtained by clipping the hedge with a pair of light shears, and the expense would be very slight. The trees might also be planted at 6 feet apart and treated in the same way as tea bushes, or they might be planted 12 feet apart and trained as pyramids, or again planted 4 feet apart and alternate plants coppiced in alternate years."

Propagation, Cultivation, etc.—Mr. Nock states :—"Camphor plants are best and most easily propagated from seeds. The seeds do not keep well, and should be sown as soon as possible after ripening. They ripen in Japan, which at present is the only important source of seed, in October and November, and should be ordered some time in advance so as to obtain them as soon as they are ripe. I find it a good plan to soak the seed in water for twenty-four to forty-eight hours before sowing, agitating the water occasionally. The best seeds being heavier will sink to the bottom, and these should be sown thinly by themselves; the lighter ones should be sown thickly, as only a small percentage will germinate.

"The seeds should be sown in well-prepared beds of sandy loam and leaf mould; they should be sown from $\frac{1}{2}$ to $\frac{3}{4}$ inch deep, making the bed firm, but not tight. The beds should be kept shaded and just moist. Too much wet will cause the young seedlings to damp off, and if allowed to get too dry the germs will quickly dry up and die.

"We have been most successful when the seed has been sown in boxes (made of $\frac{1}{2}$-inch wood) 18 by 13 by $3\frac{1}{2}$ inches filled with the kind of soil described above. The boxes are handy to lift about, and can be easily protected from heavy rain and strong sun. Sheds made after the style of the old cinchona seed sheds answer well for standing the boxes in, and if made light and airy would do well to sow the seeds in direct, but care should be taken not to allow the young plants to be 'drawn.'

"We find it a good plan to prick out the seedlings into supply baskets as soon as they are large enough to handle comfortably, or transplant them into beds, placing the plants 6 inches apart every way, and keeping them shaded and watered until they begin to grow, when they will bear the full light of the sun, but will require to be freely watered in dry weather.

"When the plants are from 9 to 15 inches high they are at their best for final planting, but if the weather is unsuitable they may be kept in the nursery till they are 2 feet high, or until good planting weather occurs, viz. dull, showery weather. In such weather they require very little shading and soon take hold of the soil.

"Cuttings do not strike root readily, and only under certain conditions will they be successful. If the prevailing weather should be too dry they soon go off, and if too wet and cold they decay before the roots are formed. We have had batches of cuttings with 70 per cent. beginning to 'callous' over and young shoots forming, that have gone off after three or four days of rough weather—cold high winds and heavy rains—and others that have gone the same way after a week of dry sunny weather. The favourable conditions are equable heat, light, and moisture; with these, and wood for cuttings in a proper state, a large percentage will strike root and make good plants.

"The nursery beds for seeds as well as cuttings should be made in a well-drained situation, and as near water as possible.

The beds may be any length and from 3 to 4 feet wide. The soil for cuttings should be composed as follows :—One part good sandy loam, one part leaf mould, and one part clean sharp sand (to this it would be beneficial to add a good sprinkling of powdered charcoal), all thoroughly mixed. The soil should be 6 to 9 inches deep. A layer of good sharp sand one inch thick should be laid on the surface. As a protection against hot sun and heavy rains it would be well to put a roof of thatch over the beds in the form of a shed, but it should be constructed with open sides to allow plenty of light and air. A shed 4 feet wide, with a lean-to roof on stout posts, open at the back and front, will be found a useful size. The posts should be 6 feet high in front and 3 feet 6 inches at the back. The roof may be thatch shingles, or other light material. If more than one is required, a space 4 feet wide should be left between the sheds to give room for watering, weeding, and general attention.

"The best material for cuttings is that from straight, healthy, and well-matured shoots of the current year's growth, not too soft or too hard. If too hard, they will not root readily, and if too soft they will be liable to damp off. The cuttings may be ot any size from the thickness of a lead-pencil to $\frac{3}{4}$-inch diameter. They should be cut into lengths of from 6 to 9 inches. A clean cut with a very sharp knife immediately below a joint to form the base of the cutting is of the greatest importance. If the cut portion is torn or jagged, or too far away from the joint, it is almost certain to decay, though it may remain green for a long time.

"The operation for inserting the cuttings is best done by opening a trench with a sharp spade so as to form a straight edge. The prepared cuttings should be laid against this and the soil pressed firmly round them. They should be placed in rows 9 to 12 inches apart, and 3 inches apart in the rows, and at a sufficient depth to leave only two or three buds above the surface.

"The sooner the cuttings are made and put in after being taken from the trees the better. After the cuttings are put in the beds should be watered to settle the soil, and if in the open they must be carefully shaded, and sunlight must be only gradually let in as they become rooted and can bear it.

"If all goes well, they should be rooted in two to three months, but they will not be ready for planting out for three or four months.

"Camphor may also be propagated by 'layers.' The operation of 'layering' is very simple. The shoots should be bent down to the soil. The branch at the bend should be cut half-way through, then cutting upwards for about $1\frac{1}{2}$ to 2 inches, so as to form a tongue. The cut portion must be kept apart by a slight twist, or by placing a small stone in the cleft. The shoot should then be pegged down firmly into a groove made in the soil for its reception and covered with soil. The end of the shoot must be kept upright by tying it to a stick.

"Another simple way is to split the branch at the bend where it is to be laid in the ground, making the split about 2 inches long and keeping the cut parts open by inserting a piece of wood or stone. Peg down well into the soil and stake. The ends of the shoot should be cut back a few inches with a sharp knife."

Synthetical Camphor.—In 1900 a process was patented by the Ampère Electro-Chemical Company of New Jersey for the manufacture of camphor from oil of turpentine, and in 1903 a new company, the Port Chester Chemical Company, was formed to manufacture camphor by this process.

In general terms, the process is as follows:—By heating turpentine with anhydrous oxalic acid two compounds are formed, viz. bornyl hydrogen oxalate and bornyl formate, which, when subjected to steam distillation in the presence of alkali, yield camphor and borneol respectively. Borneol is readily converted into camphor by oxidation, so that on treating the mixture with an oxidising agent almost the whole of the product is obtained as camphor.

The mixture of turpentine and anhydrous oxalic acid is heated in steam-jacketed tanks, and when the reaction is complete, the liquid mass is pumped into stills, alkali is added, and the mixture is distilled by the aid of live steam. From the distillate the mixture of borneol and camphor is recovered by fractional distillation.

The crude product is filter pressed, washed free from all traces of oil and treated with an oxidising agent to convert the borneol into camphor. The crude camphor is centrifugalised and then

purified by sublimation. The yield of camphor is said to be 25 to 30 per cent. of the weight of the turpentine.

It will be seen, however, that this process depends on the low price of turpentine for its successful competition with the Formosan natural product, and also on the utilisation of bye-products. This process is at a great disadvantage at present owing to the high price prevailing for oil of turpentine.

"**Artificial Camphor.**"—Many attempts have from time to time been made to find a good substitute for camphor, for the manufacture of celluloid, and at one time the substance known as "artificial camphor" was used to a considerable extent for this purpose. This substance—really a terpene hydrochloride—is obtained by passing hydrochloric acid gas into well-cooled oil of turpentine or pinene and subsequently purifying the crystalline product so obtained. Although possessing physical properties similar to those of camphor, it differs very greatly from it in chemical composition, containing, as it does, chlorine. Recently naphthalene has also been applied in this connection, and has, it is stated, in some cases been found to be a satisfactory substitute.

At present there seems to be little prospect of natural camphor being largely replaced by either "synthetic camphor" or a camphor substitute, since the only product—oil of turpentine—which, so far as is known at present, can be used as a source of these materials, is becoming more expensive owing to the demand exceeding the supply. Further, it is probable that natural camphor could be placed on the market at prices much below those now prevailing, and still prove remunerative to exporters, and it is doubtful whether "synthetic camphor" could under such conditions compete with the natural product in price.

DEVELOPMENT OF VOLATILE OILS IN PLANTS.

ALTHOUGH during the last few decades much information has been acquired with regard to the nature and composition of volatile oils, but little attention has been paid until recently to the equally important subject of the method of development

of these products in plants. It is now known that most volatile oils owe the peculiar aroma or flavour which causes them to be in commercial demand to one or more special constituent, and that the aroma or flavour of these constituents is frequently masked or at least modified by the presence of other components of the oil of little or no value. Thus in ordinary oil of lemon the lemon flavour is due principally to the presence of the substance known as citral, but there is also present a terpene, known as limonene, which is comparatively inert as a flavouring agent. It is obvious that a careful study of the processes by which volatile oils are developed in plants might lead to the discovery of methods of cultivation by means of which the formation of these secondary inert constituents might be partially or even wholly avoided.

During the last few years a series of investigations of this kind have been carried on in France by Charabot and Hébert, and some interesting results have been obtained, which have been published from time to time in the *Bulletin de la Société Chimique de Paris*. The most important of these results are summarised in the following account.

A fact of considerable interest is observed in a study of the constituents of many volatile oils, namely, that the oxygenated compounds, to which the flavour or odour of the oil is usually due, are generally accompanied by the corresponding terpenes. The oxygenated constituent may differ from the hydrocarbon in chemical composition: (1) by the elements of water, as in the case of terpene alcohols such as linalool $C_{10}H_{18}O$, which is related to the terpene limonene $C_{10}H_{16}$, and borneol $C_{10}H_{18}O$ related to the terpene camphene $C_{10}H_{16}$; (2) by an atom of oxygen, as in the case of aldehydes—*e. g.* citral $C_{10}H_{16}O$ and the terpene limonene $C_{10}H_{16}$; or (3) by the substitution of an atom of oxygen for two atoms of hydrogen, as in carvone $C_{10}H_{14}O$ and limonene $C_{10}H_{16}$.

The same oil may contain terpene alcohols, their esters, and ketones or aldehydes corresponding to these alcohols, together with one or more terpenes, and generally speaking is a mixture of constituents which, under certain conditions, are convertible one into the other.

In considering the development of volatile oils in plants,

therefore, the first problem which arises consists in ascertaining the means by which the various constituents of the oil are formed at the expense of each other in the plant, and the conditions under which these conversions occur.

The oil first examined by Charabot and Hébert was bergamot, yielded by the rind of the unripe fruit of *Citrus bergamia*, the chief constituents of which are linalool and its acetic ester, linalyl acetate, together with the terpenes *d*-limonene and dipentene.

Two samples of oil were examined, one prepared from fully-developed green fruit, the other from properly ripe fruit, both taken from the same tree. The characters of these two samples of oil were as follows :—

	Oil from green fruit.	Oil from ripe fruit.
Specific gravity at 14° C.	0·882	0·883
Specific gravity at 18° C.	0·879	0·880
Optical rotation (in 100-mm. tube)	+14° 38′	+20° 30′
Free acids (calculated as acetic acid), per cent.	0·289	0·283
Free linalool, per cent.	15·1	5·6
Linalyl acetate ,,	33·8	38·2
Total linalool ,,	41·7	35·6

The optical rotation indicates the presence of a larger quantity of terpene (*d*-limonene) in the ripe fruit than in the green fruit, whilst the diminution in the content of both free and total linalool and the increase in the percentage of linalyl acetate in the oil from the ripe fruit indicate that the ester content increases, during the process of ripening, at the expense of the free linalool.

The oils after saponification gave the following constants :—

	Oil from green fruit.	Oil from ripe fruit.
Specific gravity at 16° C.	0·8625	0·8615
Optical rotation (in 100-mm. tube)	+13° 52′	+20° 10′

The diminution in the specific gravity of the oil from the ripe fruit is greater than that from the green fruit after saponification, the observation that this oil is richer in linalyl acetate than that from the unripe fruit being thus confirmed.

The saponified oils, when fractionated under the same conditions in order to ascertain their terpene content, gave the following results:—

	Oil from green fruit.			Oil from ripe fruit.		
	Vol. of distillate. Per cent.	Optical rotation (100-mm. tube).	Sp. gr. at 18°.	Vol. of distillate. Per cent.	Optical rotation (100-mm. tube).	Sp. gr. at 18°.
177°–183°, chiefly terpenes	58·1	+30° 10′	0·857	65·6	+34°	0·855
183°–200°, chiefly linalool	22·5	+2° 14′	—	18·7	+4°	—

From these results it follows that the terpene content also increases at the expense of the linalool during the ripening of the fruit. Further experiments showed that the relative proportions of limonene and dipentene were practically the same in both oils.

The high boiling residue [bergaptene $C_{11}H_5O_3$ (OCH_3)], obtained by evaporating the oils under the same conditions, was also found to be smaller in the oil from the ripe fruit.

During the ripening process, therefore, the following changes occur:—

(1) The free acids diminish slightly.

(2) The linalyl acetate increases.

(3) The free and total linalool decreases.

(4) The terpenes increase, whilst their relative proportions remain constant.

(5) The bergaptene diminishes.

The fact that the linalool decreases while the ester increases shows that the former must appear in the plant before the ester. The free acid (acetic) then acting on the linalool esterifies a part and dehydrates another portion, producing on the one hand linalyl acetate, and on the other the terpenes limonene and dipentene. This view is corroborated by the fact that the terpenes increase during esterification without any variation in their relative proportions, which shows that their formation is simultaneous. The active period of formation of linalool is the time of development of the fruit, esterification accompanied by dehydration of the alcohol being effected especially during the ripening process.

To verify the conclusions arrived at in the case of bergamot

oil, Charabot extended his experiments to oil of lavender, which, according to Bertram and Walbaum (*Journ. f. prakt. Chem.*, (2), vol. 45, p. 590), consists chiefly of linalool free and combined with acetic, valerianic, butyric and other acids, together with small quantities of geraniol and its esters, sesquiterpenes and traces of pinene and cineol.

To ascertain the changes which lavender oil undergoes during the development of the plant, three samples of oil were prepared, viz. (1) from plants bearing buds, (2) from flowering plants, (3) from plants after flowering.

These oils had the following physical and chemical constants—

	1 Budding plants.	2 Flowering plants.	3 Plant after flowering.
Specific gravity at 15° C.	0·8849	0·8854	0·8821
Optical rotation (in 100-mm. tube)	−6°32′	−6°48′	−6° 50′
Linalyl acetate, per cent.	36·6	40·4	39·75
Free linalool, ,,	21·0	16·7	18·9
Free acid (acetic) in 1000 cc.s of water of distillation	0·5241 gr.	0·4716 gr.	0·3846 gr.
Total linalool, per cent.	49·8	48·4	50·25

These results show that the proportion of free and total alcohol (linalool) diminishes until the flowers are completely expanded, while at the same time the amounts of esters increase; when the flowers have faded the reverse process begins, and the oil becomes richer in alcohol and the ester content diminishes.

The conclusions arrived at in the case of lavender oil are similar to those for bergamot oil. Here, as in the bergamot oil, esterification is accompanied by a diminution in the quantity of alcohols and in the proportion of free acids, showing that the esters are derived from the combination of the acids and the alcohols. Under these conditions, during the development of the plant, the alcohols are partly esterified and partly dehydrated. As soon as esterification is complete, which is the case when the plant is beginning to wither, an appreciable increase in the alcohol content takes place. The destruction of the alcohol in lavender oil is less marked during esterification than in bergamot oil, which would be expected from the fact that, in the former oil, the terpenes are less abundant.

Further research has shown that, in other cases also, the formation of esters takes place during the development of the green parts of the plant, and is accompanied by dehydration of a smaller or larger quantity of the alcohol, when this constituent easily parts with the elements of water, as in the case of linalool. This elimination of water, by means of which esters and terpenes are simultaneously formed, takes place in the green parts of the plant and is probably due to the activity of the chlorophyll.

In order to follow the changes and migrations of linalool in plants, Charabot also examined the oil from the orange plant (*Citrus bigaradia*), which fulfils the conditions required, namely, that it contains the volatile oil in leaves, flowers and fruit.

The researches of Pierre, and those of Berthelot and André among others, have shown that the immediate principles elaborated in the leaves travel through the flowers and enter the fruit either in their original state or slightly modified.

An essence prepared from orange leaves which have attained their maximum coloration possesses a rotation of $-1^\circ 30'$ only, as compared with the rotation of -5° to -6° for a normal essence (from a mixture of young sprouts and leaves), and contains not more than 50 per cent. of esters instead of 60 per cent. as in the normal essence.

When the oil reaches the flower it is dextro-rotatory, and the proportion of limonene is much greater ; the proportion of geraniol to linalool also increases in the flower whilst the ester content and the total alcohols decrease. When the oil has reached the rind of the orange fruit, the proportion of limonene becomes considerable while the alcohols have almost completely disappeared, the linalool having by dehydration been converted into limonene in the parts where the activity of the chlorophyll is greatest, and the geraniol having been converted into citral in the organs which most energetically fix oxygen.

The oil next examined in the continuation of these researches was oil of peppermint (*Mentha piperita*), which contains the secondary alcohol, menthol, and the corresponding ketone, menthone.

Four samples of oil were examined, extracted from plants in different stages of development. (1) Oil from whole plants before

the appearance of buds (yield, 0·1515 per cent.); (2) from plants after the formation of buds, (*a*) from plants with inflorescence stripped (yield, 0·1239 per cent.), (*b*) from the buds (yield, 0·2829 per cent.); (3) oil from flowering plants (yield, 0·1950 per cent.).

The following table gives the chemical and physical characteristics of the four samples:

	Oil from plants before budding.	Oil from budding plants.		Oil from flowering plants.
		(*a*) leaves.	(*b*) buds.	
Specific gravity at 18° C.	0·9025	0·9016	0·9081	0·9200
Rotation at 18° C. (100 mm.)	− 24° 10′	− 26°	− 20° 15′	− 2° 37′
Menthol esters (calculated as acetate), per cent.	3·7	10·3	7·5	10·7
Combined menthol, per cent.	2·9	8·1	5·9	8·4
Free menthol, per cent.	44·3	42·2	29·9	32·1
Total menthol, ,,	47·2	50·3	35·8	40·5
Menthone, ,,	5·2	4·2	16·7	10·2

If in the second stage the plant had been distilled without separating the buds, the oil would have contained 9·6 per cent. of esters, or 7·6 per cent. of combined menthol, and 39 per cent. of free menthol (*i.e.* 46 per cent. of total menthol), and 7·5 per cent. of menthone.

At the commencement of growth, therefore, the essence is rich in menthol; a small proportion of this alcohol is found in the combined state, and menthone only exists in small quantity. As the green parts develop, the proportion of combined alcohol increases, as has already been indicated for other alcohols.

The enrichment of the essence in esters takes place in the leaves, but when the oil migrates towards the flowering apex of the plant it becomes poorer in esters. The final result is an increase in the total content of the esters in the oil from the whole plant, due to the relatively greater development which the green parts undergo. The proportion of menthone, small at the commencement of the formation of inflorescences, increases constantly during their development, while at the same time the total menthol diminishes. Thus the oil extracted from plants systematically deprived of their inflorescences only contains a small quantity of menthone, but is rich in free menthol and its esters.

On the contrary, the essence prepared from the inflorescences, even when young, contains a large quantity of menthone and

relatively small proportions of menthol and its esters. The formation of esters takes place in the green parts of the plant, as was observed in the case of linalool in bergamot, orange and lavender oils, while the menthone is formed more especially in the flower. This latter fact is confirmed by an observation made by Charabot in 1898, that when the peppermint plant was attacked by insects the larger part of the menthone disappeared at the same time as the flowers. The menthol formed during the development of the green parts of the plant is partly esterified in the leaves, the esterification, as before, being a consequence of the activity of the chlorophyll. Finally, when the inflorescences are formed a part of the oil accumulates in them, and the menthol in this oil, partly in the free state and partly combined, becomes oxidised to menthone. Similar conclusions have been arrived at by M. Curtel (*Ann. des Sciences Naturelles*, 8th series, Vol. vi., p. 221).

If the conclusions arrived at in the case of peppermint oil are generally applicable, it follows that during the period of most active carbon-assimilation, *i.e.* the period of most rapid growth of the plant, alcohols and esters are chiefly produced, and only small quantities of these substances are converted into aldehydes and ketones, whereas during a period of slow growth the excess of oxygen absorbed in the respiratory process effects the conversion of larger quantities of alcohols and esters into aldehydes and ketones.

In order to investigate this problem, Charabot examined oil of wormwood (*Artemisia absinthium*), using (1) oil prepared from plants which had developed very slowly (yield, 0·1429 per cent.), (2) oil from full-grown plants (yield, 0·2450 per cent.).

The principal constituents of this oil are the ketone, thujone, and the corresponding alcohol, thujol; the following table shows the chief physical and chemical characteristics of the two samples of oil used :—

	1 Oil from plants which had developed very slowly.	2 Oil from full-grown plants.
Specific gravity at 24° C.	0·9307	0·9253
Esters (calculated as acetate), per cent.	9·7	13·1
Combined thujol, per cent.	7·6	10·3
Free thujol, per cent.	9·0	9·2
Total thujol, ,,	16·6	19·5
Thujone, ,,	43·1	35·0

These results show that during the period of active growth, the oil is appreciably enriched in esters of thujol, but that during a period of slow growth a larger proportion of the thujol which is formed is transformed into thujone.

The conclusions arrived at in the case of wormwood oil are thus in accord with those formulated in previous researches on menthone and menthol esters. During the period of active growth, not only does the weight of the plant increase considerably, but the proportion of volatile oil is nearly doubled, and a large quantity of thujol is formed. An increase in the energy of the assimilatory functions and a decrease in the respiratory activity renders the quantity of oxygen fixed by the plant insufficient to convert as much thujol into thujone as during the period of slow growth. The conversion of thujol into thujone has not ceased entirely, since the relative proportion between the thujone and the weight of the plant has increased, but it has been reduced considerably, since the proportion of thujone expressed relatively to the oil has diminished. The relative content of thujol and its esters, however, has increased, and it is evident therefore that during the period of most active growth the formation of the alcohol and its esters predominates over their transformation into thujone.

In the course of investigations on the distribution of essential oil in the mandarin and orange trees, Charabot and Hébert found the oil in the stem to be less soluble in the sap of the plant than that in the leaves, especially in the case of old organs. Experiments were therefore carried out with the object of ascertaining whether such conditions of solubility are peculiar to the odorous substances, or whether they are the general rule for the distribution of the substances of the plant. When the organs were fully developed, the leaf was found to contain the largest proportion of essential oil and also of other soluble organic and inorganic matters, while the amount was smallest in the root; in general, during the development of an organ the proportion of soluble matter diminishes, but in the leaf, however, it only varies slightly, since the phenomenon of assimilation maintains an equilibrium between the relative amounts of soluble and insoluble matter. In the stem the decrease of soluble organic matter is due really to a transformation of soluble into

insoluble matter (*e.g.* carbohydrates into lignin), and to the transference of soluble constituents to growing points, especially to the inflorescence.

The investigation was extended to the sweet basil (*Ocimum basilicum*). The essential oil in this case is contained in all the aërial portions of the plant, and the plant was examined in four different stages of growth: (1) before flowering (preponderance of leaves), (2) at the commencement of flowering (preponderance of stems), (3) in full bloom (excess of flowers), (4) after flowering (maturity of seeds), and the following observations were made.

The weight of essential oil in all the green organs increases during the period preceding the formation of the inflorescence; between the commencement of flowering and the time of full bloom, the proportion of oil in the green parts diminishes appreciably whilst that in the flowers increases. After fructification, the amount of oil in the green parts increases, whilst the amount of oil in the inflorescence decreases to such an extent that the total quantity of oil in the plant is also diminished. These results indicate that the oil is first carried from leaf to flower, together with the carbohydrates which, after having been rendered soluble, go to nourish the latter organ. After fructification, when the carbohydrates have been deposited as reserve materials, the flow of nutritive principles to the flower ceases; part of the essential oil has been consumed but the remainder seems to return to the green organs. The *rôle* played by essential oils does not therefore appear to be entirely independent of the mechanism which aids in the accumulation and transference of reserve material.

Comparing the different organs of the sweet basil from the point of view of the essential oil, it is found that the root contains none, the stem only a small proportion, and that the leaf and inflorescence are richest in the oil.

Comparative experiments on etiolated and normal plants of *Ocimum basilicum* have shown a considerable difference in the quantity of the essential oil and in the proportions of the constituents of the oil obtained from each. The plant when kept from the light was found to consume the essential oil, and especially the terpenes, while in the normal plant the terpenes

and other constituents, and the total quantity of oil, were found to increase.

These results indicate that the essential oils are not without value in the vital economy of the plant. When the plant in the dark can no longer assimilate carbon dioxide from the air, these substances are available as food material, and probably contribute to the formation of tissue or furnish the energy of which the plant is deprived by the absence of light.

POISONOUS PROPERTIES OF THE BEANS OF *PHASEOLUS LUNATUS.*

IN previous numbers of the *Bulletin of the Imperial Institute* (1903, Vol. i., pp. 15 and 112), attention was directed to the poisonous nature of the uncultivated forms of these beans, and it was shown that this toxicity is due to the formation of prussic acid when the beans are moistened with water.

The scientific aspect of the question is fully discussed in a paper communicated by Professor Dunstan and Dr. Henry to the Royal Society, and published in the *Proceedings of the Royal Society for* 1903, in which it is shown that the prussic acid is formed from a glucoside, contained in varying amount in the bean.

It was also pointed out that the beans imported into this country from the East Indies as a cattle food under the names of "Rangoon," "Paigya," or "Burma" beans, are derived from cultivated forms of *Phaseolus lunatus*, and that whilst some of these (the white beans) yield no prussic acid, others (the pink beans with small purple spots) yield traces of the acid usually too small to be harmful.

At the same time the danger of using the coloured beans of *Phaseolus lunatus* as a feeding stuff were pointed out, and in particular it was indicated that changed climatic or cultural conditions in any locality in which the cultivated forms of the bean are produced, might lead in some cases to the production of poisonous forms, and that, further, there was some difficulty in distinguishing by mere inspection between the poisonous wild beans, and the coloured forms produced by more or less careful

cultivation, and that consequently if a large trade in these beans were developed, as seemed probable, there would always be risk of confusion between the poisonous and non-poisonous forms. It appears that this latter difficulty has already arisen, both in this country and in Holland. Quite recently the Imperial Institute has received from three different firms of importers in this country, samples of beans of *Phaseolus lunatus* said to be imported from Java. These beans had seed coats exhibiting the dark purple, or buff colours with purple spots, which seem to characterise the poisonous variety of the beans of *Phaseolus lunatus*. The samples were examined in the Scientific and Technical Department of the Imperial Institute, and found to yield quantities of prussic acid varying from 0·03 to 0·16 per cent. These quantities of acid are about the same as those furnished by the wild Mauritius beans derived from *Phaseolus lunatus* previously examined at the Imperial Institute (*loc. cit.*), which are well known to be poisonous. These results were communicated to the firms importing these beans from Java, and fortunately it was possible in a number of cases to prevent the sale of further consignments in this country. The beans seem to have been imported, however, in comparatively large quantities, and through a number of different firms, and it has consequently been impossible for all the importers to be warned, with the result that a number of poisoning cases among cattle have occurred. In one case several sheep have been poisoned, and recently Mr. G. F. Scott Elliot, of Newton, Dumfries, has notified the Imperial Institute that twenty valuable cows have been poisoned in that locality by bean-meal. A sample of the beans said to have been used in preparing this meal was sent to the Imperial Institute by Mr. Scott Elliot, and these were identified as undoubtedly the beans of *Phaseolus lunatus*, having all the appearance of these beans as recently imported from Java. This latter case has been referred to in several newspapers, and there is reason to believe that several others have occurred, particulars of which have not become public.

The same trouble seems to have arisen in Holland. The Imperial Institute has been informed by the Director of the Kolonial Museum at Haarlem that several cases of poisoning

both among cattle and human beings have been traced to the consumption of these beans.

A distinction must be drawn between these highly-toxic beans, as produced in Java and Mauritius by *Phaseolus lunatus* when growing wild or in a state of partial cultivation, and those produced in India and elsewhere and obtained from the same plant in a state of more or less careful cultivation, and imported as "Rangoon" or "Burma" beans. The Indian beans obtained from *Phaseolus lunatus* occur in two forms: (1) quite white and (2) pink with purple spots. Both these Indian forms have been examined at the Imperial Institute, and the former have been found not to yield any prussic acid, whilst the pink beans marked with purple spots have yielded only traces of the acid and may not be harmful.

The white cultivated beans are also produced in Java, and they have been examined by Dr. Treub of Buitenzorg, who has informed the Director of the Imperial Institute that he has obtained no prussic acid from them. Samples of white *Phaseolus lunatus* beans, probably of South American origin, purchased in France, have also been examined at the Imperial Institute and found to yield no prussic acid. It seems probable therefore that the white beans yielded by the carefully-cultivated variety of *Phaseolus lunatus* are quite harmless, and so long as trade in this product is confined to this form there seems to be no risk of danger. With regard to the other Indian form with a pink seed coat, marked with purple spots, it is probable that this does not usually yield sufficient prussic acid to be harmful, and the dangers in using it lie in the possibility of more than the usual amount of prussic acid being developed owing to unusual climatic or cultural conditions, and in the chance of the toxic uncultivated forms of the bean being mistaken for this variety and sold in place of it. It therefore is obvious that great caution will be necessary in using as cattle-food any but the white form of these beans.

NOTICES OF RECENT LITERATURE.

NEW BOOKS.

ON SILK AND THE SILKWORM. Translated from the French of Laurent de l'Arbousset by Elizabeth Wardle and edited by

her father, Sir Thomas Wardle, F.C.S., F.G.S., President of the Silk Association of Great Britain and Ireland. Pp. viii + 287. (Leek: W. H. Eaton, 1905.)

Sericiculture was first undertaken in France at the end of the fifteenth century, but for many years made but little progress. A rapid increase took place, however, during 1710–20, and in the latter year the production of silk became more regular, Avignon alone possessing 400 silk mills. At this time, 4,000 or 5,000 tons of cocoons were produced annually, and between 1760 and 1790 the quantity rose to 6,000 or 7,000 tons, but diminished towards the end of the century during the revolutionary period. The amount of silk produced was 400 tons in 1750–60, and continued to increase until 1790, when it reached 500 tons. From 1790 to the end of the century, the output of silk remained stationary or perhaps gradually became less, but during the early years of the new century it rapidly increased. Between 1820 and 1830 the production reached 1,000 tons, and during the following decade amounted to from 1,000 to 1,500 tons, finally reaching 2,000 tons per annum during 1840–55. Unfortunately at about this time a serious disease, known as "pebrine," broke out among the silkworms and the amount of silk produced fell rapidly to 500 tons. M. Pasteur devoted his attention to the disease, and after two years' study succeeded in discovering its cause and a means of its prevention. The losses caused by this disease, however, caused sericiculture to become neglected in France, and the industry has never regained its former vigour. The cocoon harvests at the present time amount to only 6,000 or 7,000 tons, instead of 20,000 to 26,000 tons in 1846–55, whereby it is estimated that France sustains an annual loss of 3 or 4 million pounds sterling.

The book under consideration was written with the object of encouraging sericiculture in France as a cottage industry and of thus increasing the output of silk without diminishing the profits from other employments. The author expresses the hope that by this means the wealth of the country and the well-being of the rural population may be increased, and he looks forward to the time when the production of silk will have regained the position which it held in 1855.

An account is given of the cultivation of the mulberry tree, the

rearing of silkworms, and the treatment and preservation of the cocoons.

The work is written in simple language, gives practical details of the various operations involved in sericiculture, and will be useful alike to those already engaged in the industry and to those who are undertaking it for the first time, and from this point of view may be commended to the notice of those interested in the introduction or extension of sericiculture in India and other British Colonies and Dependencies. The translation has been carefully made and the reputation of its English Editor is a sufficient guarantee of the accuracy of the descriptions of the processes and operations dealt with.

SUGAR AND THE SUGAR CANE. AN ELEMENTARY TREATISE ON THE AGRICULTURE OF THE SUGAR CANE, AND ON THE MANUFACTURE OF CANE SUGAR. By Noël Deerr. Pp. viii + 396 + xix. (Altrincham, Manchester: Norman Rodger, 1905.)

This work gives an account of the whole industry of producing cane sugar, from the planting of the cane to the separation of the crystals from the concentrated juice. The different varieties of the cane, its cultivation, manuring, harvesting, and the diseases and enemies that attack it, are described in the first quarter of the volume; an account of the extraction of the juice, and of the machinery and processes by which the sugar is obtained in the factory is next given, and explanations of various points in these processes are discussed.

The methods of examining and analysing the products at various stages, together with a chapter on the manufacture of rum, form the last quarter of the book. In dealing with the control of a modern factory, the author remarks that from the extraction of the juice in the crushing mill, to the distillery, the work must be conducted as a huge chemical experiment, and efforts must be made to account for every pound of sugar entering the factory; the losses should be located and, if possible, corrected.

Numerous numerical data and tables accompany the descriptions, and there are 130 illustrations, of which nine are coloured representations of the principal varieties of cultivated canes.

METHODS OF CHEMICAL CONTROL IN CANE SUGAR

FACTORIES. By H. C. Prinsen Geerligs, Director of the West Java Sugar Experiment Station, Pekalongan, Java. Pp. viii + 86. (Altrincham, Manchester: Norman Rodger, 1905.)

This book is designed to assist the manager and chemists of a sugar factory in their work. It comprises directions for sampling and analysing sugar cane, bagasse, filter press cakes, juices, syrup, masse-cuites, molasses, and sugar; and the methods for calculating the results.

Schemes for keeping records of these results are drawn up with a view to keeping a thorough control over the working of the factory, also of the fields of the plantation; they consist of daily reports, monthly reports, and a final account of the sucrose extracted and lost.

A specification of the necessary apparatus, and numerous tables to facilitate the calculations involved in making the records, are added. This, and the book dealt with in the preceding 'Notice,' may be recommended to the attention of planters and others interested in sugar cane cultivation and cane sugar production in British Colonies.

IN REMOTEST BAROTSELAND. By Colonel Colin Harding, C.M.G., F.R.G.S., Acting Administrator of North-Western Rhodesia, Commandant Barotse Native Police. Pp. xv + 413. (London: Hurst and Blackett, Ltd., 1905.)

This book contains an interesting account of a journey of over 8,000 miles through the wildest and most remote parts of Barotseland, the territory of King Lewanika, an extensive country which is now under the protection of the Imperial Government and is administered by the British South Africa Company. A description is given of the visits which were made to all the important chiefs *en route*, and of the various incidents and difficulties of the expedition. The book is divided into four sections.

The first part gives an account of the author's journey up the Zambesi from the Victoria Falls to its source, a distance of nearly 1,000 miles. From a geographical point of view, some valuable information was obtained regarding the source and course of the river. Both the river and the confluences of its tributaries were thoroughly explored, and much entirely new

country was traversed. Careful observations were made, especially with reference to latitude. From the source of the river, the expedition returned overland to Nyakatoro.

In the second section, a description is given of the journey from Nyakatoro westwards to Chisamba-Bihé, including an account of visits to the Portuguese forts. The expedition proceeded from Bihé to Lialui, *viâ* Kalomo West, the whole distance covered amounting to 1,090 miles.

The third part deals with the author's journey from Lialui to the Victoria Falls, and thence to Kalomo, Monze, and the junction of the Zambesi and Kafue rivers, the point where the boundaries of North-Western, North-Eastern, and Southern Rhodesia meet.

The fourth section gives a brief summary of the expedition from Lualui to Kasempa (250 miles north-west of Lialui), and thence northwards to the source of the Kabompo river, a distance of about 200 miles, through a country well watered and apparently healthy, but nearly denuded of natives by slave traders. The results of this journey were the mapping out of the Kabompo river from its source, the selection of sites for new forts, and the liberation of a large number of slaves. The work concludes with some reminiscences of King Lewanika's visit to England.

The book is well illustrated, and furnished with a map of the routes followed by the author.

THE NATIVE RACES OF SOUTH AFRICA. A HISTORY OF THE INTRUSION OF THE HOTTENTOTS AND BANTU INTO THE HUNTING-GROUNDS OF THE BUSHMEN, THE ABORIGINES OF THE COUNTRY. By George W. Stow, F.G.S., F.R.G.S. Edited by George McCall Theal, Litt.D., LL.D.; formerly Keeper of the Archives of the Cape Colony and now Colonial Historiographer. Pp. xvi + 618. (London: Swan, Sonnenschein & Co., Ltd.; and New York: The Macmillan Co., 1905.)

This volume describes the Bushmen, their cave-dwellings, hunting expeditions, strange ceremonial dances, love of music and games, customs relating to marriage and burial, and their racial characters. Whole tribes of the Bushmen seem to have been annihilated when the hunting-grounds in which they had long been undisturbed were invaded by stronger tribes

pouring in from tropical Africa; these invaders being, it is stated, first the nomadic Hottentots, and next the Bachoanas. The latter, unlike the Bushmen, cultivated the soil, and were the most skilful workers in metals in South Africa; they also carved wooden utensils, such as spoons and bowls, and made pottery. Next came the Kaffirs armed with assegais and ox-hide shields, who settled in the coast districts. The later invading tribes from the north were the Abatembu, Amampondo, Amazulu, and Matabili, the latter being particularly noted for the short assegai which they used for stabbing at close quarters. They were followed by the Natal tribes. Later came the early Dutch settlers, and finally the British.

This book is a valuable contribution to ethnology, but it is also full of incident. Very striking descriptions are given of the raids of the Koranas, and the struggles of the Griquas, occupiers of the parts of the valley of the Vaal now famous for the diamond fields, against the endeavours, ultimately successful, of European settlers to take possession of their lands, while among many other bits of history a short account is given of Bloem, supposed to have been a German or Dutch outlaw, who, after killing many natives and raiding their cattle, formed his kraal near the spring or fountain which now supplies the town of Bloemfontein, named after him. An impressive description is also given of an incident known to have occurred less than a century ago: the invasion of the Mantatee horde.

Mr. Stow was a settler on the extreme border of Cape Colony in 1843. His manuscript, incomplete at the time of his death, was purchased by Miss Lloyd, the principal authority on the Bushmen, and entrusted by her to Dr. Theal, the Colonial Historiographer, to be edited, as no production of such value upon the native races of South Africa had previously been published. The work is well indexed, and contains illustrations of Bushman cave-paintings, and one showing the manner in which the Bushmen converted their single-stringed bow into a four-stringed harp-like musical instrument.

COLONY OF NATAL. REPORT OF THE COAL TESTING COMMITTEE. Pp. 90. (Maritzburg: O. Davis & Sons, 1905.)

The report contains the results of a series of boiler tests on

Natal coals carried out under the direction of a Committee of colonial officials, including the Commissioner of Mines, the Locomotive Superintendent, and the Chief Inspector of Boilers.

The objects of the tests were to determine the relative speeds of burning of the various coals under given conditions, and the relative efficiencies of the same coal at different speeds of burning. Two boilers (a Reid locomotive boiler and a Marshall portable boiler), having different ratios of heating surface to grate area, were installed at Durban for this purpose. Four tests of each coal were made in each boiler, viz. "8 hours' ordinary draught," "7 hours' light draught," "6 hours' medium draught,' and "4 hours' full draught." A similar series of tests was also made with a typical Welsh coal. The Welsh coal was found to contain a considerable amount of dust, and was therefore screened on a ¼-inch mesh sieve, which passed 15 per cent.

The results show that much of the Natal coal has a very high evaporative power, in some cases only slightly inferior to Welsh steam coal, and that various qualities of coal, from quick-burning bituminous types to anthracitic varieties, are available in the Colony.

A series of tables in the Report gives (1) the speed of burning per square foot of grate area; (2) the equivalent evaporative powers per pound of coal at different pressures of draught; (3) the amount and nature of the unconsumed residue and other less important factors. The results should prove useful for general reference.

THE OXFORD ATLAS OF THE BRITISH COLONIES. Part I. (Oxford: William Stanford & Co., Ltd., 1905.)

Part I. of the Oxford Atlas deals with British Africa in seventeen maps, all of which have been specially prepared. Diagrams illustrating the amount of rainfall, variation of temperature, and distribution of vegetation are included, in addition to a series of blank test maps, which are intended for class purposes in schools.

THE RECORDS OF THE CAPE COLONY. Prepared by George McCall Theal, Litt.D., LL.D. Vols. xxxiv., xxxv., xxxvi., Pp. i–x, 1–545; Pp. i–ix, 1–489; Pp. 1–475. (Printed for the Government of the Cape Colony, 1905.)

The publication of the Records of the Cape Colony was begun in 1897, and since that time thirty-six volumes have been issued. The original intention was to render available the text of the letters and documents in the Public Record Office, London, relating to the Cape Colony down to the close of 1827, when a new system of government was introduced. The editor, however, has deemed it advisable to include in the last volume the correspondence down to 1831, relating to the suppression of the slave trade, thus rendering the series more complete.

Vol. xxxv. contains an Index to the preceding five volumes, and Vol. xxxvi. is devoted to a Register of Contents of the whole series.

CANADIAN LIFE IN TOWN AND COUNTRY. By Henry J. Morgan and Lawrence I. Burpee. Pp. 1–267. (London : George Newnes, Ltd., 1905.)

The authors, as indicated in the title of their book, sketch the general conditions of life in Canada. The physical features and historical events are touched upon in passing, and attention is principally devoted to such topics as the French-Canadian, the militia, sports and amusements, education and journalism, literature and art, religious thought, and other features of modern social life in Canada. The chapter on the political and judicial system sketches broadly the development of the scheme of government and enumerates the duties and responsibilities of the principal officers. Under the heading of "Trade and Commerce," a brief though fairly comprehensive summary is given of the natural resources and the principal manufacturing industries of the country. Numerous illustrations add to the interest of the volume, and the bibliography which is appended should prove of assistance to those interested in Canada.

THE BOOK OF TRINIDAD. Edited by T. B. Jackson. Pp. 1–154. (Trinidad : Muir Marshall & Co., 1904.)

The scope of this volume is that of a general handbook to Trinidad and Tobago, the principal economic and other topics being treated in a series of independent articles by Government officials and others. Professor P. Carmody, the Island Chemist summarises the industrial resources of the Colony, under the heads of agriculture, mining, manufactures and other industries.

Comparison of the exports for 1903 and ten years previously shows clearly the great advances made by cacao, which has superseded sugar as the chief product of Trinidad. The main features of each industry are summarised, and the lines along which progress is being, or should be, made are indicated. Agricultural education, for instance, is considered in direct relationship to the improvements likely to result in agricultural practice from more wide-spread knowledge of its principles. Sugar manufacture is dealt with in rather more detail in a popular account of a day's work at the Usine St. Madeleine. H. Caraciolo treats of the botany, cultivation, and pests of the cacao tree, and of the preparation of the "bean." The forest resources are discussed by C. F. Rogers, Forest Officer, who enumerates and describes the principal timbers, and sketches the main features of the Government forest policy. The important subject of trade with Venezuela is summarised by the Collector of Customs. F. Dodsworth deals with the "Pitch Lake and Manjak Mining" (compare *Bulletin of the Imperial Institute*, 1903, Vol. i., p. 51), and other chapters afford information on historical events, folklore and superstitions, and sport in Trinidad, and a general account of the island of Tobago. A special feature of the book is the large number of illustrations, including habit pictures of several of the principal fruits and other economic plants, views of the pitch lake, public buildings and racial types. On the whole, there has been brought together a useful account of the general conditions and natural resources of the island.

A PRACTICAL GUIDE TO COOKERY IN WEST AFRICA AND THE TROPICS. By Sister Cockburn. Pp. 1–160. (London: The Scientific Press, Ltd.)

The authoress, formerly of the Colonial Nursing Service, Sierra Leone, has brought together in this volume a large number of easily-prepared recipes "likely to be acceptable as providing a little pleasant change in the rather limited menu of the ordinary West African *cuisine*, particularly in the case of invalids or convalescents."

RIVER, SAND AND SUN. By Minna C. Gollock. Pp. 1–184. (London: Church Missionary House, 1906.)

This volume contains an account of the work of the Church

Missionary Society in Egypt as observed during a series of visits made in the winter months. Incidentally notes are given on general conditions, agricultural methods, and native customs, which are enhanced in value by the large number of reproductions of photographs with which the book is illustrated.

THE CEYLON HANDBOOK AND DIRECTORY, AND COMPENDIUM OF USEFUL INFORMATION FOR 1905–6. Compiled and edited by J. Ferguson, C.M.G. Pp. i–xi and 1–1364. (Colombo: A. and J. Ferguson, 1905.)

It would be impossible in the space of a brief review to attempt even to mention the subjects on which information is afforded by this encyclopædic work. Since the first issue was published in 1859, twenty-seven editions have appeared, and the general features of the book should be well known to all interested in Ceylon.

The importance of the rapidly-developing Para rubber industry of the Colony has doubtless led to the choice of the frontispiece, which represents a portion of the Heneratgodha Botanic Gardens, the first Para rubber plantation in the East. It is estimated that there is now in Ceylon the equivalent of 45,000 acres under this crop, or, at 175 to the acre, about 7,000,000 plants of various ages.

The planting review which forms the introductory matter is an epitome of the history of agricultural enterprise in the Colony, the acreage under the principal crops is given, with statistical summaries and illustrations of most of the points of practical interest.

The figures showing the world's output of the products in which Ceylon is particularly interested are of great interest, and enable a proper perspective view to be obtained of the relative importance of Ceylon's contribution of each staple to the world's markets.

THE BERMUDA ALMANAC. Pp. 1–248. 1905. (Printed at the *Royal Gazette* Office, Hamilton, Bermuda.)

An illustrated almanac now in its sixty-second year of issue. In addition to the usual information contained in such publications, the book includes a useful, well-arranged "Tourists' Guide" of 130 pages, containing much of interest to the visitor.

"VERB. SAP." ON GOING TO WEST AFRICA. By Alan Field, F.R.G.S. Pp. 166. (London: John Bale, Sons & Danielsson, Ltd.)

This book is intended to serve as a practical guide for persons who are proceeding to the West Coast of Africa, especially for those who are going out for the first time. It has been written with special reference to Northern Nigeria, but its most important features are applicable to the whole of the West Coast. For the benefit of those without previous experience of the tropics, the question of a suitable outfit and its cost is fully discussed, and the information is supplemented by a list of firms who make a speciality of colonial outfits. A sketch is given of the journey along the coast from Sierra Leone to Forçados, and thence by the Niger to Lokoja, and two chapters are devoted to an account of the conditions of European life in Northern Nigeria. The climate and the precautions to be observed for the preservation of health are dealt with in a special chapter, and a due observance of the many useful hints upon this important subject will, no doubt, tend to reduce the dangers incident to residence on the West Coast. Sections on sport and on the native languages are included, together with some notes for lady nurses, and some historical and general information relating to West African affairs. The book summarises in convenient form a great deal of useful information relative to life in the tropics, and will, no doubt, be of service to those for whose benefit it has been written, although the book has no pretensions to be anything more than a light and readable introduction to the subject.

COLONIAL PUBLICATIONS.

COPIES of the following publications, dealing with the development of the British Colonies, have recently been received, and are available for distribution at the Central Stand in the Exhibition Galleries, free of charge (for complete list see cover).

Canada.

GEOGRAPHY OF THE DOMINION OF CANADA. Issued by direction of the Minister of the Interior. This book contains an account of the geography, resources and development of Canada, and is intended for

use in schools and for the guidance of would-be settlers. There are several maps of the Provinces, and the growth of Canadian industries is illustrated by graphic diagrams.

CANADA IN A NUTSHELL. Issued under the authority of the Minister of the Interior by the Commissioner of Emigration for Canada. Pp. 1–32. Brief illustrated notes on Canada especially intended for emigrants.

CANADIAN NATIONAL PARK. Published by Direction of the Minister of the Interior, 1905. Pp. 1–63. The Canadian National Park is the largest of the great parks of the world, comprising in all 5,732 square miles. This publication attempts, with the aid of illustrations, some in colour, to give an idea of the scenery, the plants and the animals of this tract of country.

BOOK OF CARTOONS. Published by the authority of the Minister of the Interior. A series of cartoons, in colour, indicating the agricultural wealth of Western Canada.

WORDS OF TESTIMONY FROM SETTLERS IN CANADA. Issued by the authority of the Minister of the Interior. Pp. 1–32. Extracts from letters from settlers in Canada received by the Canadian Commissioner of Emigration, London.

HOME BUILDING IN CANADA. Issued under the authority of the Minister of the Interior, by the Commissioner of Emigration for Canada. Pp. 1–15. A reproduction of "Canada and Our Public Schools" from the London *Standard*, together with other accounts of the advantages Canada offers to settlers. This pamphlet is illustrated.

SPORTSMEN'S MAP OF THE DOMINION OF CANADA. Issued by the Canadian Pacific Railway. A map of the Dominion showing the railway and canoe routes, and indicating broadly the principal localities for game and fish.

THE NEW HIGHWAY TO THE ORIENT, ACROSS THE MOUNTAINS, PRAIRIES AND RIVERS OF CANADA. Issued by the Canadian Pacific Railway Company, 1905. Pp. 1–60. An illustrated account of the country traversed by the Canadian Pacific Railway, with incidental notes on crops, mineral products and game.

THE CHALLENGE OF THE MOUNTAINS. Issued by the Canadian Pacific Railway Company, 1905. Pp. 1–92. An illustrated handbook to the Canadian Rocky Mountains.

AROUND THE WORLD BY THE CANADIAN PACIFIC ROUTE. A map and accompanying information of use to travellers.

MONTREAL. Published by the Montreal Business Men's League. A small, well-illustrated pamphlet containing an account of the history,

trade and general life of Montreal, with especial reference to the attractions of the city for the tourist, and as a place of residence. Attention is drawn to the advantages offered as an athletic and sporting centre, and an abstract of the fishing and game laws of the Province of Quebec is appended.

STORY OF A MANITOBA SETTLER. Official. This leaflet gives an account of the successful management of farms at Treherne and Swan River Valley.

RANCHING IN THE CANADIAN NORTH-WEST. Pp. 1–71. This publication is principally concerned with Southern Alberta and Western Assiniboia, which constitute the ranching section of the North-West Territories. Much useful information is given: notes on the climate, grazing regulations, educational facilities, the principal grasses—including their local and botanical names and chemical composition—ranch management, irrigation, local retail prices of provisions, hardware, etc., wages. There is a map and numerous illustrations.

PROSPERITY FOLLOWS SETTLEMENT IN WESTERN CANADA. Issued under the direction of the Minister of the Interior. Pp. 1–112. 1905. The pamphlet, which is illustrated, contains a large number of letters from English, Scotch and Irish settlers, recounting their experiences in Western Canada. The known wheat-growing area in the country is given as 171,000,000 acres, of which 5,000,000 acres are now under cultivation.

WHEAT GROWING IN CANADA. By William Saunders. Reprinted from the *Canadian Magazine*, 1904. A short popular account of the possibilities of Canada as a wheat-growing country, together with a brief *résumé* of the results of experiments in the breeding of new varieties of wheats. A full account of these experiments was published in the *Bulletin of the Imperial Institute*, 1904, Vol. ii., pp. 207–210.

COMPARATIVE VALUES OF THE DIFFERENT GRADES OF WHEAT IN 1904. (Bulletin No. 18, Department of Agriculture, North-West Territories.) This bulletin gives the results of analyses, milling and baking tests of the different wheats of the 1904 crop, which were carried out in the Chemical Department of the Ontario Agricultural College, Quelph.

THE UNDEVELOPED AREAS OF THE GREAT INTERIOR OF BRITISH COLUMBIA. (Bulletin No. 9, Bureau of Provincial Information. 1904. Pp. 1–50.) This is a revised edition of a previous bulletin, called for by the demand for information on this region, and especially on the Bulkeley Valley and Ootsa Lake districts. The extent and character of the country and the means of access are described, and detailed information as to the agricultural, forest, and mineral resources afforded by extracts from official reports. The rules for the occupation of Crown Lands are appended.

NEW WESTMINSTER, BRITISH COLUMBIA. THE ROYAL CITY OF THE WEST. Published by the New Westminster Tourist Association. An illustrated pamphlet setting forth the attractions of New Westminster for the tourist, sportsman, or permanent resident.

GLORIOUS KOOTENAY. Issued by the Tourist Association of Kootenay. An illustrated pamphlet summarising the attractions which the Kootenay District of British Columbia offers to those in search of sport and scenery. An epitome is given of the Game Laws.

South Africa.

HANDBOOK OF INFORMATION FOR PASSENGERS. Issued by the Union Castle Line. Pp. 1–111. Plans and maps. 18th edition, 1905. A pamphlet to be of use in the first instance to passengers. The map shows clearly the distances between the chief ports, and the principal products and industries of South Africa from the Cape to the north of Rhodesia.

THE UNION CASTLE LINE ILLUSTRATED HANDBOOK ON SOUTH AFRICA. By A. Samler Brown. Issued by the Union Castle Line, 1903. Pp. 1–78. One map. The book brings together in a small compass a mass of information about South Africa. Mining, labour, the principal towns, productions and industries are described and illustrated, whilst there is a general account of the characteristics of the country.

Western Australia.

GOVERNMENT RAILWAYS AND TRAMWAYS. By Authority, 1905. In addition to time tables the pamphlet contains general information on the rail and tramways, and a railway map of the State.

WESTERN AUSTRALIA. SOUTH-WESTERN DIVISION. THE LAND FOR SETTLERS. Issued by the West Australian Government. Two illustrated pamphlets have been issued under this name, and deal generally with the resources and prospects of this portion of Western Australia, "as a land specially suited to agricultural settlement."

New South Wales.

NOTES ON THE SCOPE FOR SETTLEMENT. Official. The attractions of New South Wales as a land for the settler are briefly but clearly stated. The possibilites of the dairy industry are especially emphasised.

FREEHOLD FARMS RESERVED BY THE GOVERNMENT OF NEW SOUTH WALES FOR BRITISH SETTLERS. Official. A description of the fifty farms which have been reserved in the well-known Myall Creek district of New South Wales. Tables of rainfall and temperature are given, together with information as to the best methods of farming the holdings. A few of the more important provisions of the Closer Settlement Act are appended.

Queensland.

QUEENSLAND, 1905. Issued by the Government of Queensland. The official almanac, directory and gazetteer of Queensland. An appreciation of the State as a home for settlers forms a well-illustrated introduction to the volume.

Tasmania.

CROWN LANDS GUIDE, 1905. Published by the authority of the Minister of Lands and Works. Pp. 1–161. The seventh edition of the *Crown Lands Guide* contains a summary of the Land Laws and Regulations of the State. Detailed information is afforded as to general conditions under which the Crown Lands may be purchased, occupied by means of grazing or other licences, leased for pastoral and other purposes, or held under licence for saw-mill and timber cutting. A feature of this edition is a series of reports by the stock, agriculture and forestry experts dealing with these several industries. Special attention is devoted to the timber industry, and notes are given on the principal commercial woods of the State. The volume contains a large number of "economic" and other illustrations, and a map.

VOL. III, 1905

INDEX